Shelve

Scientific Investigations

TWENTY-EIGHTH

ANNUAL REPORT

OF THE

FISHERY BOARD FOR SCOTLAND,

Being for the Year 1909.

IN THREE PARTS.

PART I.—GENERAL REPORT.
PART II.—REPORT ON SALMON FISHERIES.
PART III.—SCIENTIFIC INVESTIGATIONS.

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Presented to Parliament by Command of His Majesty.

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CONTENTS.

SCIENTIFIC REPORTS.

TWENTY-EIGHTH ANNUAL REPORT.

TO THE RIGHT HONOURABLE

LORD PENTLAND,

His Majesty's Secretary for Scotland.

OFFICE OF THE FISHERY BOARD
FOR SCOTLAND,
EDINBURGH, 15*th December*, 1910.

MAY IT PLEASE YOUR LORDSHIP,

In continuation of our Twenty-eighth Annual Report we have the honour to submit—

PART III.—SCIENTIFIC INVESTIGATIONS.

GENERAL STATEMENT.

This part of the Twenty-eighth Annual Report deals with the scientific investigations which have been conducted by the Board in 1909 in connection with the sea fisheries of Scotland, so far as they have been completed, by means of the Parliamentary Vote granted for the purpose.

The scientific work has, as usual, been carried out under the supervision of Dr. T. Wemyss Fulton, the Scientific Superintendent under the Board, the researches having been undertaken chiefly at the Board's Marine Laboratory, Bay of Nigg, Aberdeen, and partly in the Clyde, in connection more particularly with the herring fishery there. The hatchery for sea fishes is also situated at the Bay of Nigg, Aberdeen, and a statement of the work done at it during the year will be found below.

As was explained in previous Reports, the investigations into the condition of the fishing-grounds in the Moray Firth and Aberdeen Bay, which were conducted for a number of years by means of commercial steam trawlers engaged for the purpose, have not been continued, for reasons formerly stated; but the statistics of the catches of line fishermen within the Moray Firth are regularly collected, and the old trawling stations of the "Garland" are now being periodically examined with a beam-trawl by the "Goldseeker," and a report dealing with the investigations is in course of preparation.

In the Firth of Clyde, and in particular in Loch Fyne, the investigation into the herring fishery which has been in progress for the last few years was continued, and observations on the temperature of the water and the relative abundance of plankton were made as frequently and regularly as circumstances allowed. This subject is dealt with more fully below.

Among the researches in progress, but not yet completed, may be mentioned the relation between the salmon fishery and the herring fishery in Loch Fyne, the destruction of immature herrings by sea birds, and the reproduction of fishes.

The Hatching of Plaice.

During the season of 1909 the hatching-work was continued at the Bay of Nigg as in previous years. The methods employed have been fully described in some previous Reports, the essential features being the retention of the adult fishes in a large tidal pond, where the eggs are shed and fertilised in a natural way during the spawning season; the collection of the floating eggs from the pond and their transference to the hatching apparatus, where also the larval fishes are kept for some time after hatching occurs.

In the course of the previous autumn considerable numbers of live plaice were obtained by the "Goldseeker" in the Moray Firth and added to the stock already existing in the spawning pond. In consequence of the increased supply of spawners, the number of eggs collected in the course of the season was larger than in the previous year, amounting to about 19,749,000, as compared with 15,332,000 in 1908—the increase thus being about 4,417,000. The first eggs were collected on 21st January, and collections were made thereafter almost daily till 26th May, when a few thousands were obtained. The spawning in the pond thus extended over eighteen weeks, but, as usual, by far the greater proportion of the eggs were shed in March, and particularly just after the middle of the month. The number of eggs obtained in each month of the season, and the percentages, were as follows:—

	Number of Eggs.	Percentage.
January, - - - -	87,000	0·44
February, - - -	2,890,000	14·6
March, - - - -	10,860,000	55·0
April, - - - -	5,387,000	27·2
May, - - - -	525,000	2·6

The number of dead eggs which were removed from the hatching apparatus was estimated at 3,134,000, or a little under 16 per cent., which is a lower proportion than usual. The specific gravity of the water during the season varied from 26·2 to 27·4, and the temperature from 2·6° C. to 11·4° C.

The number of living fry of the plaice obtained from the hatching apparatus in the course of the season was estimated at about 16,615,000, as compared with 12,296,000 in the previous year—an increase of 4,319,000. They were liberated in the sea in nine lots, between 25th February and 12th June. About half of them were

taken to the waters off the northern part of the coast of Aberdeenshire and liberated in the neighbourhood of Fraserburgh, while the remainder were liberated in the waters of Aberdeen Bay and off Girdleness. It is satisfactory to be able to state that the hatching operations are much appreciated by the fishermen along the coast of Aberdeenshire. Petitions on their behalf for the liberation of the fry have been received from many of the fishing villages from Rosehearty to Newburgh, and these have as far as possible been given effect to.

The number of the eggs of the plaice collected from the spawning pond, and the number of fry hatched out and liberated in the sea, since the hatchery was established at the Bay of Nigg, are as follows :—

Year.	Eggs Collected.	Fry Liberated.
1900 . . .	43,290,000	31,305,000
1901 . . .	65,377,000	51,800,000
1902 . . .	72,410,000	55,700,000
1903 . . .	65,940,000	53,600,000
1904 . . .	39,600,000	34,780,000
1905 . . .	40,110,000	24,500,000
1906 . . .	7,486,000	4,406,000
1907 . . .	1,627,000	1,282,000
1908 . . .	15,332,000	12,296,000
1909 . . .	19,749,000	16,615,000
	370,921,000	286,284,000

The decrease after 1905 was due to the fact that the services of steam trawlers in the Moray Firth and Aberdeen Bay was then abandoned, large supplies of living plaice for the spawning pond having previously been obtained in this way. It may be added that the cost of the fish-hatching work as carried on at the Bay of Nigg, in conjunction with the laboratory, is small, amounting to an estimated sum of about £80 per annum, representing the extra expenditure for coals, oils, &c., and for occasional assistance.

Investigations on the Herring Fishery of the Firth of Clyde.

Since the latter part of 1904 investigations have been carried on with reference to the herring fishery in the Firth of Clyde, and in Loch Fyne in particular, as far as the means at disposal allowed. These investigations were initiated in consequence of a failure of the fishery in Loch Fyne, a failure which unfortunately still continues. The following figures show the quantity of herrings taken in the loch during the last ten years :—

Year.	Herrings Caught.	Year.	Herrings Caught.
1900, - -	24,743 crans.	1905, - -	4,672 crans.
1901, - -	29,117 „	1906, - -	5,258 „
1902, - -	26,339 „	1907, - -	3,914 „
1903, -	21,198 „	1908, - -	4,070 „
1904, - -	7,827 „	1909, - -	3,684 „

The statistics of the Loch Fyne herring fishery extend back to the year 1854, and only in one year in that period was the quantity of herrings caught less than in 1909, and then only by a few crans—namely, in 1873, when 3,648 crans were landed. The poor results of the fishing in recent years is not equalled in the history of the fishery, so far as known, for in the last great depression there were only three years—1872–1874—when the quantity was less than 10,000 crans. Towards the end of June last year there were indications that a considerable shoal of herrings had entered Lower Loch Fyne, and in the month of July a fair fishing was carried on—the aggregate catch for that month being 2,966 crans, as compared with 3,684 crans for the whole year. The herrings, however, did not penetrate far up the loch, and they very soon left it altogether.

Similar and apparently unaccountable fluctuations in the herring fishery, more especially in lochs or arms of the sea, are of not infrequent occurrence, and have been attributed to various causes; but no explanation that has yet been given can be regarded as altogether satisfactory. Variations in the temperature of the sea and in the quantity of floating food upon which the herring subsists are believed by many to be the principal factors in producing fluctuations in the fishery. The investigations now being made are designed to show whether or not this explanation is the right one. Periodic observations are taken of the temperature of the water and of the abundance of the floating herring-food, and these will be continued until the herrings have returned to Loch Fyne in something like their former abundance. There is no good reason to suppose that the present scarcity will not be followed by years of good fishing, such as have succeeded to the periods of depression in the past.

The Influence of Temperature on the Development of the Eggs of the Herring.

At the request of the Government of New Zealand, a series of experiments on the retardation of the development of the eggs of the herring has been carried on at the Marine Laboratory during the last two seasons. The object of the New Zealand Government is to ascertain whether it is possible to delay the development, and thus the hatching, of the ova of the herring for a period sufficiently prolonged to enable them to be carried to New Zealand and dealt with there—a period which is estimated at about 50 days. In last year's Report an account of the first series of experiments was given by Dr. H. C. Williamson, the general result being that it was shown to be possible to delay the development of the eggs for the period required, though the great proportion of them died at an earlier date. The main cause of the mortality was deficient aeration of the water, as it was difficult to secure a sufficient flow cooled to the necessary temperature. The further experiments which were made by Dr. Williamson are described in the present Report, other forms of apparatus having been made use of. The cooling of the water was successfully attained and a much more even temperature secured, but the difficulties of the aeration of the water were not overcome, and although a few of the eggs survived for a period of fifty days, none of them hatched. Check experiments with uncooled water showed that

the mortality was owing, not to the low temperature, but to deficient aeration. At the request of the New Zealand authorities, these experiments are being continued, and it is hoped that it will be possible to devise an apparatus which will enable the difficulties referred to to be surmounted.

The Food of the Halibut.

An extensive research on the nature of the food of this important fish was made by Dr. Thomas Scott, who contributes a paper to the present Report setting forth the results of the investigation. The stomachs of 1076 halibut were examined, the fish ranging in length from 18 inches to five feet; they were caught at various parts of the North Sea and North Atlantic and landed at Aberdeen. About one-third of the stomachs, or nearly 34 per cent., were found to be empty, or contained food in such a condition that identification of the organisms composing it could not be made. A very considerable proportion of the food of the halibut was shown to consist of fishes, of which twenty species were determined, the most common being the haddock and the whiting, and it was found that the larger halibuts were more prone to a fish diet than the smaller ones. Crustaceans, and in particular the Norwegian lobster (*Nephrops*) and hermit crabs, were common in many of the stomachs examined, and cuttle-fishes of several species were not infrequent, but echinoderms were sparingly represented, and annelids hardly at all.

Diseases of Fishes.

The subject of the diseases to which fishes are liable is now receiving more attention than was the case previously. In the present Report, Dr. A. G. Anderson, now the Medical Officer of Health of Rochdale, describes a bacteriological investigation which he made of an outbreak of disease among the fishes at the Marine Laboratory. Some haddocks and whitings which were caught in the neighbourhood of a sewer were conveyed to the Laboratory to replenish the tanks, and a few of them were observed to have small ulcerations on the skin. Within a few days the healthy fish which were previously in the tank became affected in like manner, and shortly afterwards they all died. The outflow from those tanks was into the large pond, in which live plaice were contained, and later on a number of these fish became also affected and subsequently died. The bacteriological investigations made at Marischal College by Dr. Anderson revealed the presence of various bacteria, including bacillus coli communis, which made it probable that the fish had died from a form of septicæmic poisoning, possibly caused by infection from the sewage-borne micro-organisms. A few years ago a similar outbreak of disease was observed to have occurred among the fishes in the pond at the Marine Laboratory, Port Erin. It appears that marine fishes are not so susceptible to microbal attacks as are fresh-water fishes, and that amongst the former flat-fishes are less susceptible than round fishes, as haddocks and whitings. The evidence, moreover, indicates that fish do not suffer readily from

the ingestion of bacteria, nor from the presence of sewage in the water, so long as the gills are not clogged; but, on the other hand, such outbreaks of disease are of some significance to Health Authorities in whose sanitary areas sewage is being deposited in rivers, estuaries, or on the seashore.

Abnormal and Diseased Conditions of Fishes.

Dr. Williamson contributes a paper to this Report, in which he describes various abnormalities and diseased conditions which he has observed among fishes, such as tumours in the cod, the lemon dab, the viviparous blenny, and other forms, and also cases of hermaphroditism in the cod, a species in which that condition is not uncommon. He also describes and figures the larvæ of the angler *(Lophius)*, and gives an account of its eggs and those of the halibut, the conger, and the tusk. The ripe egg of the conger has not yet been identified with certainty: the largest yolked eggs observed by Dr. Williamson were 0·6 millimetres in diameter, and were found in fishes captured at the end of October and the beginning of November. The same gentleman has also written a paper, illustrated with five plates, describing the larval stages of various species of crabs. The study of these larvæ is important with reference to the general question of development and the discrimination of the forms which go to make up the plankton. This paper is not included in the present Report, but is published separately as a Stationery Office publication.

Parasites of Fishes.

Several papers dealing with the parasites of fishes have appeared in previous Reports of the Board, and to the present one Dr. T. Scott contributes a description, illustrated with two plates, of four parasitic trematodes, one of which is now described for the first time. One of them was obtained from the gills of the gar-fish, and the others from the non-edible *Chimæra monstrosa.*

We have the honour to be,

Your Lordship's most obedient Servants,

ANGUS SUTHERLAND, *Chairman.*
D. CRAWFORD, *Deputy-Chairman.*
D'ARCY W. THOMPSON.
W. R. DUGUID.
L. MILLOY.
D. MEARNS.
H. WATSON.

DAVID T. JONES, *Secretary.*

SCIENTIFIC REPORTS.

I.—REPORT ON LARVAL AND LATER STAGES OF CERTAIN DECAPOD CRUSTACEA (WITH FIVE PLATES). By H. CHAS. WILLIAMSON, M.A., D.Sc., F.R.S.E., Marine Laboratory, Aberdeen.

Issued separately as Stationery Office Publication, price 2s. 3d.

II.—REPORT ON THE OPERATIONS AT THE MARINE FISH HATCHERY, BAY OF NIGG, ABERDEEN, IN 1909. By Dr. T. WEMYSS FULTON, F.R.S.E., Scientific Superintendent.

In the course of the autumn of 1908 several hundreds of live plaice were added to the stock of adults in the spawning-pond, the fish having been caught by the Fishery Investigation steamer *Goldseeker* in the Moray Firth and brought to Aberdeen. The mortality among these fishes, owing often to the rough passage from the fishing-grounds, was sometimes considerable after they had been placed in the pond, and, as the fact is not without importance with reference to the methods adopted in the "marking experiments" (to ascertain the migrations of fishes), it may be mentioned that of 193 placed in the pond on 12th September, 55 had died before the 29th of that month, and of 267 put in on 23rd October, 30 had succumbed by the next day, and other 36 within a week.

In consequence of the increased supplies of spawners, the number of eggs collected from the spawning-pond in the course of the season was larger than in the previous year, amounting to about 19,749,000, as compared with 15,332,000 in 1908, the increase thus being about 4,417,000.

The first eggs were collected on 21st January, which is about the usual time for them to appear, and collections were made thereafter almost daily until 26th May, when a few thousands were obtained. The spawning of the plaice thus extended over eighteen weeks, but, as usual, by far the greater proportion of the eggs were shed in March, and particularly just after the middle of the month. It will be observed from the appended table that the spawning was considerable at the end of February, when the temperature of the water was unusually high for the season, and that it was checked later when the temperature fell several degrees lower. The numbers of eggs obtained in each month of the season, and the percentages, are given in the subjoined table:—

Month.	Number of Eggs. Collected.	Percentage.
January	87,000	0·44
February	2,890,000	14·6
March	10,860,000	55·0
April	5,387,000	27·2
May	525,000	2·6
	19,749,000	

The number of dead eggs which were removed from the hatching apparatus (including, however, the shells of those which had hatched) was estimated at 3,134,000, or a little under 16 per cent., which is a very low

proportion, attributable for the most part to a fuller supply of water and better filtering arrangements, and to the utilisation of the filtered water again during the occurrence of storms, as described in last report.

The number of living fry obtained in the course of the season was estimated at about 16,615,000, as compared with 12,296,000 in the previous year. They were put out into the sea in nine lots, the first on the 25th February, and the last on the 12th June, as described in Table II. appended. About half of the fry were taken to the northern part of the coast of Aberdeenshire and liberated off Sandhaven, near Fraserburgh, Mr. W. J. Caird, of Sandhaven, kindly rendering much assistance in making the arrangements. The remainder were liberated off Aberdeen Bay and Girdleness.

The fishermen on the coast of Aberdeenshire have petitioned on several occasions for fry to be "planted" in the locality of their fishing grounds, requests of the kind having been received from many of the villages from Rosehearty to Cruden. Their plaice-fishing has recently been very much better than it was before, and they attribute the improvement to the planting of the fry along the coast during the last five or six years. In such cases it is not an easy matter to obtain convincing evidence, but inquiries at other parts of the coast show that the plaice-fishing had not improved in the same way at other localities, and from the results of the extensive experiments carried on for thirteen years in Lochfyne, and described in the Annual Report for 1907, it is quite likely the fishermen are right in their opinion, namely, that their increased catch of plaice is due to the operations of the hatchery.

The number of the eggs of the plaice collected from the spawning-pond, and the number of the fry hatched out and liberated in the sea, in the various years since the hatchery was established at the Bay of Nigg, are as follows:—

	Eggs Collected.	Fry Produced.
1900	43,290,000	31,305,000
1901	65,377,000	51,800,000
1902	72,410,000	55,700,000
1903	65,940,000	53,600,000
1904	39,600,000	34,780,000
1905	40,110,000	24,500,000
1906	7,486,000	4,406,000
1907	1,627,000	1,282,000
1908	15,332,000	12,296,000
1909	19,749,000	16,615,000
	370,921,000	286,284,000

It will be seen that, although the numbers in the last two years are greater than they were in 1906 and 1907, they fall far short of what they were a few years earlier, when large supplies of adult fish were being obtained by means of the trawlers whose services were secured for work in the Moray Firth.

It has to be added that the cost of the fish-hatching work as carried on at the Bay of Nigg, in combination with the Marine Laboratory, is comparatively small, amounting to about £80 per annum, so far as it can be estimated, the amount representing extra coals, oils, etc., food for the fishes, and occasional assistance to the attendant.

The appended Tables show the progress at the hatchery from day to day; the temperature and specific gravity of the water on the beach, in the pond, and in the hatching apparatus; and also the particulars referring to the liberation of the fry:—

TABLE I.—Showing the Daily Progress at the Hatchery, and the Temperature and Specific Gravity of the Water.

Date.	Eggs Collected.	Dead Eggs Removed.	Beach.		Pond.		Hatchery.
			Temp. °C.	Specific Gravity.	Temp. °C.	Specific Gravity.	Temp. °C.
1909.							
Jan. 21	} 10,000 {	..	6·6	27·4	4·0	27·4	6·0
„ 22		..	6·6	27·4	3·8	27·4	6·0
„ 23	..	..	7·0	27·4	4·2	27·4	5·6
„ 25	10,000	..	5·0	27·4	2·8	27·4	3·4
„ 26	27,000	..	5·4	27·2	3·0	27·2	3·8
„ 27	10,000	..	4·8	27·2	2·6	27·0	3·8
„ 28	10,000	..	5·4	27·2	2·6	27·2	3·2
„ 29	20,000	..	5·4	27·2	2·4	27·2	4·0
„ 30	..	..	4·2	27·4	1·5	27·4	3·0
Feb. 1	40,000	..	4·8	27·4	1·6	27·2	2·6
„ 2	10,000	..	5·0	27·2	2·0	27·2	2·8
„ 3	..	..	5·2	27·2	4·2	27·2	5·0
„ 4	10,000	20,000	5·0	27·4	3·2	27·4	4·6
„ 5	13,000	..	5·2	27·4	3·2	27·2	4·4
„ 6	10,000	..	6·0	27·2	2·8	27·2	4·0
„ 8	30,000	..	6·0	27·4	4·2	27·4	4·8
„ 9	10,000	..	6·6	27·2	4·2	27·4	5·0
„ 10	10,000	..	6·0	27·2	4·0	27·2	5·0
„ 11	27,000	20,000	6·2	27·4	4·6	27·4	5·6
„ 12	20,000	..	5·4	27·2	4·2	27·2	5·0
„ 13	10,000	..	6·4	27·4	5·0	27·4	6·8
„ 15	20,000	..	5·8	27·2	5·4	27·2	6·0
„ 16	20,000	..	6·6	27·4	6·0	27·4	6·6
„ 17	160,000	..	7·0	27·4	6·6	27·4	6·8
„ 18	100,000	..	8·0	27·4	7·0	27·4	6·8
„ 19	120,000	..	7·6	27·4	7·0	27·4	6·8
„ 20	160,000	80,000	7·8	27·4	6·8	27·4	7·0
„ 22	240,000	..	7·0	27·4	7·0	27·2	7·2
„ 23	240,000	..	7·2	27·4	6·6	27·4	7·0
„ 24	320,000	..	7·0	27·4	5·6	27·4	6·8
„ 25	400,000	100,000	6·6	27·4	5·6	27·4	7·0
„ 26	440,000	..	7·4	27·4	6·0	27·4	7·2
„ 27	480,000	..	6·2	27·4	5·4	27·4	7·0
Mar. 1	480,000	..	6·4	27·4	4·6	27·4	6·8
„ 2	400,000	200,000	6·2	27·4	4·6	27·2	7·0
„ 3	480,000	..	6·0	27·4	3·0	27·2	7·0
„ 4	360,000	..	5·8	27·4	4·0	27·2	6·6
„ 5	240,000	..	5·0	27·4	4·0	27·2	6·6
„ 6	280,000	..	5·6	27·2	4·2	27·2	4·2
„ 8	360,000	120,000	4·0	27·2	3·8	27·2	6·0
„ 9	320,000	..	5·0	26·8	2·8	27·2	3·4
„ 10	320,000	..	4·0	26·6	2·6	27·0	3·0
„ 11	320,000	80,000	4·8	26·6	3·6	27·0	3·8
„ 12	320,000	..	5·2	27·4	3·6	27·0	4·6
„ 13	480,000	..	4·2	27·4	3·2	27·2	4·0
„ 15	600,000	100,000	4·2	27·0	3·2	27·2	3·4

TABLE I.—*continued.*

Date.	Eggs Collected.	Dead Eggs Removed.	Beach.		Pond.		Hatchery.
			Temp. ° C.	Specific Gravity.	Temp. ° C.	Specific Gravity.	Temp. ° C.
1909.							
Mar. 16	480,000	160,000	3·6	27·2	2·8	27·2	3·6
„ 17	480,000	. .	3·4	27·2	2·4	27·2	3·6
„ 18	400,000	120,000	4·8	27·4	3·2	27·2	4·2
„ 19	480,000	. .	4·8	27·4	4·0	27·2	5·0
„ 20	480,000	. .	4·6	27·2	3·8	27·2	5·0
„ 22	400,000	187,000	4·2	27·4	4·0	27·2	5·0
„ 23	440,000	. .	4·6	27·4	3·2	27·4	4·8
„ 24	400,000	. .	5·0	27·4	4·0	27·4	5·0
„ 25	480,000	120,000	6·0	27·2	4·0	27·2	5·2
„ 26	360,000	. .	6·0	27·2	4·4	27·4	5·2
„ 27	320,000	120,000	5·6	27·4	4·0	27·4	4·8
„ 29	420,000	. .	6·0	27·2	4·2	27·0	4·8
„ 30	440,000	200,000	6·6	27·0	4·6	27·0	5·0
„ 31	320,000	. .	5·0	27·2	3·8	27·2	5·0
April 1	360,000	. .	6·0	27·2	4·0	27·2	5·0
„ 2	280,000	180,000	6·6	27·0	3·6	27·0	4·6
„ 3	320,000	. .	6·8	27·0	4·4	26·8	5·0
„ 5	320,000	120,000	6·8	27·2	4·0	27·0	5·2
„ 6	400,000	160,000	7·6	27·0	5·2	27·0	5·8
„ 7	280,000	. .	6·6	27·2	4·6	27·2	5·8
„ 8	240,000	. .	7·0	27·4	5·0	27·2	5·8
„ 9	240,000	107,000	6·4	27·4	4·6	27·2	6·6
„ 10	260,000	. .	7·0	27·2	5·6	27·4	6·6
„ 12	240,000	120,000	6·6	27·0	5·4	27·2	6·4
„ 13	240,000	160,000	8·0	26·8	5·4	27·0	6·2
„ 14	200,000	. .	7·6	27·2	4·8	27·0	6·8
„ 15	180,000	80,000	8·0	27·2	4·8	27·2	6·0
„ 16	160,000	. .	6·6	27·4	6·0	27·0	7·0
„ 17	180,000	80,000	7·0	27·4	6·0	26·8	7·8
„ 19	160,000	. .	8·0	27·4	5·0	27·2	6·8
„ 20	160,000	. .	7·6	27·2	5·0	27·4	6·0
„ 21	160,000	100,000	7·4	27·2	5·0	27·4	6·0
„ 22	160,000	. .	6·2	27·0	7·0	27·0	6·4
„ 23	160,000	120,000	7·0	26·8	7·8	27·0	8·0
„ 24	107,000	. .	5·8	27·0	7·0	27·0	8·0
„ 26	200,000	80,000	5·8	27·0	8·4	27·0	7·0
„ 27	160,000	40,000	6·0	26·8	8·0	26·8	6·4
„ 28	60,000	40,000	6·2	27·0	7·6	26·4	6·4
„ 29	80,000	. .	6·4	27·2	7·4	26·4	6·2
„ 30	80,000	. .	5·4	27·2	7·4	26·2	6·0
May 1	40,000	. .	5·8	27·2	6·6	26·8	5·0
„ 3	. .	. .	6·2	27·2	7·0	27·2	5·4
„ 4	120,000	. .	7·4	27·2	7·2	27·2	7·4
„ 5	40,000	. .	6·8	27·2	7·0	27·2	7·0
„ 6	40,000	80,000	7·2	27·4	7·4	27·2	7·2
„ 7	40,000	. .	8·2	26·8	10·0	27·0	9·8
„ 8	40,000	. .	9·0	27·0	9·8	27·0	9·6

TABLE I.—*continued.*

Date.	Eggs Collected.	Dead Eggs Removed.	Beach.		Pond.		Hatchery.
			Temp. °C.	Specific Gravity.	Temp. °C.	Specific Gravity.	Temp. °C.
1909.							
May 10	20,000	. .	8·8	26·8	9·6	26·8	8·2
„ 11	20,000	20,000	9·0	24·0	10·0	27·0	9·0
„ 12	5,000	. .	8·6	25·4	9·6	26·4	8·4
„ 13	. .	. .	8·0	26·0	9·0	27·0	7·0
„ 14	40,000	. .	6·6	26·6	8·2	27·0	6·6
„ 15	20,000	. .	6·6	27·2	7·6	27·0	6·2
„ 17	20,000	5,000	7·8	27·0	8·6	27·0	7·4
„ 18	20,000	. .	7·0	27·2	8·8	27·0	7·8
„ 19	10,000	. .	7·4	27·2	9·0	27·0	8·2
„ 20	15,000	5,000	8·4	27·0	9·0	27·0	8·8
„ 21	10,000	. .	8·4	27·2	9·4	27·0	9·2
„ 22	. .	. .	10·0	27·2	10·8	27·0	10·8
„ 24	10,000	10,000	10·4	26·8	12·2	27·2	11·4
„ 25	5,000	. .	8·4	26·8	11·8	26·8	10·4
„ 26	10,000	. .	8·4	27·0	11·2	26·8	9·8
„ 27	. .	. .	8·4	27·4	11·2	27·2	9·0

TABLE II.—Showing Particulars in connection with the Distribution of Fry.

Date.	Locality.	Depth. Fms.	Surface Temperature of Sea. °F.	Specific Gravity.	Weather.	No. of Fry.
1909 Feb. 25	About 2 miles off Girdleness.	16	39·2	27·2	—	480,000
Mar. 5	About 2½ miles off Girdleness.	16	42·8	27·4	—	1,520,000
„ 22	About 3 miles off Sandhaven, near Fraserburgh.	22	44·6	27·2	Fine; wind N.W.	3,800,000
Apr. 6	About 3 miles off Sandhaven, near Fraserburgh.	20	43·0	27·0	Fine; wind S.E.	4,095,000
„ 27	About 1¾ miles east of Girdleness.	14	43·0	26·8	Fine; wind N.E.	2,200,000
May 5	About 1¾ miles east of Girdleness.	14	44·0	27·0	Fine; wind S.E.	1,600,000
„ 14	About 1¼ miles off Aberdeen Bay.	14	43·9	26·6	Showery: wind N.W.	1,600,000
„ 22	About 1 mile off Aberdeen Bay.	12	50·0	27·0	Fine; wind S.	800,000
June 12	About 1½ miles off Aberdeen Bay.	16	53·6	26·6	Fine; wind N.E.	520,000

III.—EXPERIMENT IN RETARDING THE DEVELOPMENT OF THE EGGS OF THE HERRING. By H. Chas. Williamson, M.A., D.Sc., F.R.S.E., Marine Laboratory, Aberdeen.

In the spring of 1908 I carried out some experiments on the retardation of the eggs of the herring.* A certain amount of success was achieved in prolonging the period of incubation to 50 days. At the request of the Government of New Zealand, the experiment has been continued this spring, unfortunately without success.

On the previous occasion the difficulties which were specially met with were:—(1) To cool the water and keep it at a steady temperature; (2) to aerate the eggs properly.

This year these difficulties remained to be solved. The cooling of the water was successfully attained by means of a series of iron pipes which were covered with ice. A much more even temperature was in this way obtained. The quantity of water which was lowered to the desired temperature was small, and averaged about one pint in a minute.

The second problem of the aeration of the eggs seemed to be solved by the adoption of a mechanical system, which is shown in the accompanying sketch, viz., Incubating tank. (Plate I.)

The apparatus consisted of a galvanised sheet-steel box T, measuring 35 inches in length, 16 inches in breadth, and 15 inches in depth. Inside this tank there were two revolving frames, A and B. Four glass plates bearing herring eggs were fixed on the outside surfaces of A, while five plates were set in grooves inside B. The frames revolved in consequence of the motion imparted to them by the little water-wheel. The frames were always entirely covered with water.

Two glass plates stood on edge at the lower end of the tank. The tank contained 30 gallons of water.

The tank was surrounded with crushed ice.

The water, already cooled, flowed in on to the surface at one end, and found exit from the bottom of the other end. The quantity of water varied slightly from time to time, as will be seen from the table, p. 17. It averaged one pint in a minute. For a short time during the day the flow was often increased to a pint in 30 seconds. The water never ceased running except for a few minutes at a time.

Air was blown into the water on March 31, and thereafter till the end of the experiment.

The water-wheel rotated slowly. The frame A required about 6 minutes and the frame B 10 to 15 minutes to make a complete revolution.

As on the former occasion, the spawn was divided into two portions, part being kept in uncooled water, while the remainder was treated with the cooled water. The temperature of the water is given in the following Tables.

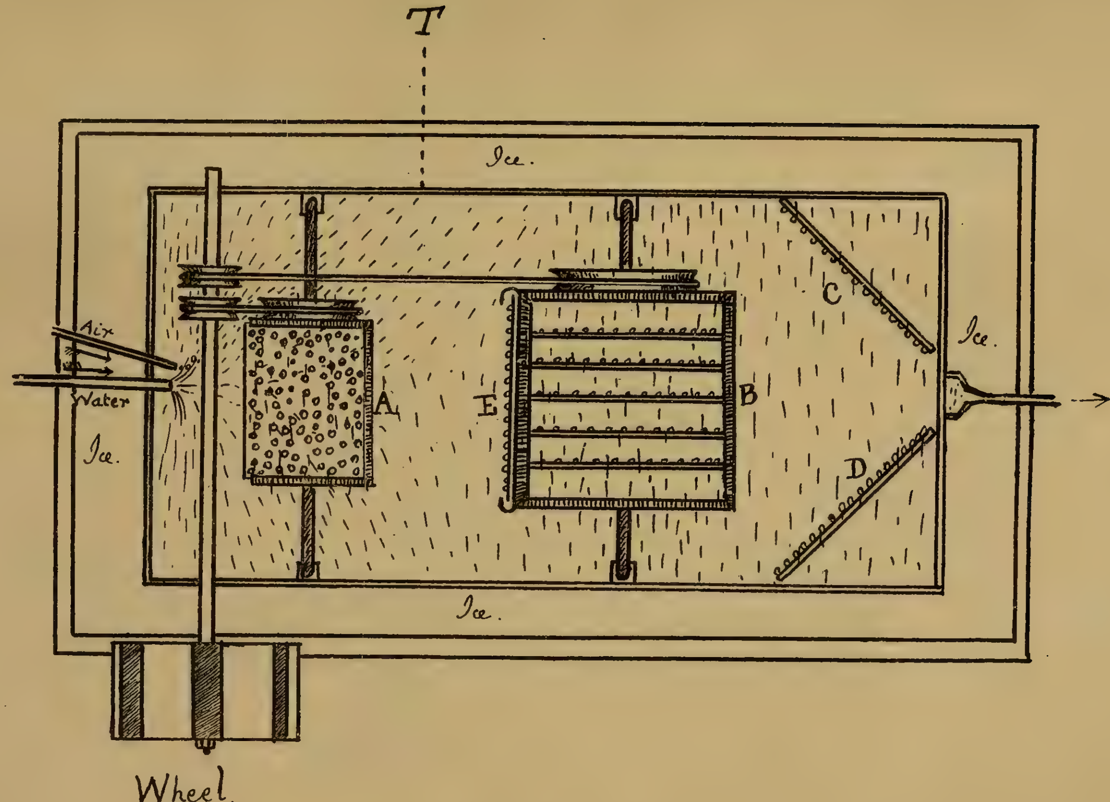
The temperatures were read by myself and by the attendants. Readings were taken during both day and night. These are given in Centigrade. The range in Fahrenheit is deduced† from the highest and lowest Centigrade readings up till March 21st. From March 22nd onwards a Fahrenheit maximum and minimum thermometer was also employed. It was set during the forenoon usually. The readings given cover, therefore, portions of two days, whereas the Centigrade readings refer to one date.

The water before being cooled was filtered through sand.

* "Experiments to show the influence of Cold in Retarding the Development of the Eggs of the Herring (*Clupea harengus*), etc." *Twenty-seventh Report of the Fishery Board for Scotland* for 1908. 1910, p. 100.

† A table of Fahrenheit equivalents to Centigrade readings, drawn up by Dr. T. Scott, was employed for this purpose.

PLATE I



INCUBATING TANK.

SCALE—⅛ inch = 1 inch.

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TEMPERATURE OF THE UNCOOLED WATER.

DATE. 1910.	Temperature Observations. ° C. Plates. 7, 8, 9.	Temperature Observations. ° C. Plates. 12, 13, 16, 18, 20.	Temperature. ° F.	DATE. 1910.	Temperature Observations. ° C. Plates. 7, 8, 9, 12, 13, 16, 18, 20.	Temperature. ° F.
Feb. 25	{**, 3·3, 3·6		37·9, 38·5	Mar. 16	4·7	40·5
" 26	2·6	3·5, 3	36·7–38·3	" 17	5·6	42·1
" 27	2·8		37	" 18	. .	. .
" 28	3·2		37·8	" 19	. .	. .
Mar. 1	3·1		37·6	" 20	4·9	40 8
" 2	4·3		39·7	" 21	5·8	42·4
" 3	5·4		41·7	" 22	. .	. .
" 4	5·2		41·4	" 23	5·6	42
" 5	4·7		40·5	" 24	6·1	43
" 6	4·8		40·6	" 25	6·7, 5·6	44, 42
" 7	5·2		41·4	" 26	6·7, 5·6	44, 42
" 8	5·3		41·5	" 27	6·7, 5·0	44, 41
" 9	6		42·8	" 28	6·7, 5·0	44, 41
" 10	5·4		41·7	" 29	6·7, 5·0	44, 41
" 11	5·1		41·2	" 30	7·2, 5·0	45, 41
" 12	4·8		40·6	" 31	8·4, 5·6	47, 42
" 13	. .		. .	Apr. 1	7·8, 6·1	46, 43
" 14	3·7		38·7	" 2-4	. .	. .
" 15	4·4		39·9	" 5	8·4, 5·0	47, 41

** Air about freezing point.

TEMPERATURE OF THE COOLED WATER.

DATE. 1910.	Temperature Observations.—° C. Plates. 1, 2, 3, 4	6, 10.	11.	14, 15, 17, 19.	Range of Temperature. ° F.	Average Quantity of Running Water supplied‡ during the 24 hours.
Feb. 24	**	. .	. .	. .	. .	. .
" 25	3·6	*3·3, 3·6	*3·3, 3·6	. .	37·9, 38·5	. .
" 26	2·6		2·6	3·5, 3	36·7, 38·3	. .
" 27	2·8, †1·8, 2·0		2·8		35·2, 37	. .
" 28	2, 2·4 2·6		3·2, †2·4, 2·6		35·6, 37·8	. .
Mar. 1	2·4, 2·5				36·3, 36·5	. .
" 2	2·6, 2·0, 1·7				35·1, 36·7	. .
" 3	2·6, 2·5, 2, 1·9, 2·0				35·4, 36·7	. .
" 4	1·0, 1·0, 1·3, 1·3, 1·4				33·8, 34·5	About 30 secs.
" 5	1·4, 1·3, 1·3, 0·6, 1·2				33·1, 34·5	40 "
" 6	1·0, 1·1, 1·3, 1·2, 1·4, 1·4				33·8, 34·5	52 "
" 7	2, 1·4, 1·3, 1·1, 1·2, 0·6				33·1, 35·6	73 "
" 8	1·6, 0·8, 0·8, 1·0, 1·8, 1·5, 0·5				32·9, 35·2	70 "
" 9	0·6, 0·6, 1·0, 0·8, 0·7, 0·8, 0·6, 0·4				32·7, 33·8	87 "
" 10	1·4, 1·2, 0·8, 0·7, 0·9, 0·6, 1·1, 1·0, 0·8				33·1, 34·5	60 "

** Weather cold ; sleet. * Air about freezing point.
† First introduction into cooled water.
‡ The amount of running water is indicated by the time (seconds) required to fill a one-pint measure (= ·6 litre).

TEMPERATURE OF THE COOLED WATER—*continued.*

DATE. 1910.		Temperature Observations.—° C.	Range of Temperature. ° F.	Average Quantity of Running Water supplied‡ during the 24 hours.
Mar.	11	0·5, 0·4, 0·6, 1·0, 1·0, 0·2	32·4, 33·8	68 secs.
,,	12	0·4, 0·4, 0·3, 0·5, 0·5, 0·8, 0·8	32·5, 33·4	58 ,,
,,	13	0·6, 0·8, 0·7, 0·7	33·1, 33·4	57 ,,
,,	14	0·6, 0·6, 0·6, 0·9, 0·7, 0 6	33 1, 33·6	59 ,,
,,	15	0·6, 0·7, 0·7, 0·7, 1·0, 1·2, 1·1, 1·6	33·1, 34·9	52 ,,
,,	16	1·9, 1·3, 1·4, 1·3, 0·9, 0·8, 0·7	33·3, 35·4	62 ,,
,,	17	1·0, 0·9. 1·0, 0·7, 0·5, 0·6	32·9, 33·8	60 ,,
,,	18	0·7, 0·7, 0·6, 0·8, 1·0, 0·7	33·1, 33·8	56 ,,
,,	19	0·5, 0·5, 0·6	32·9, 33·1	65 ,,
,,	20	1·2, 1·0, 0·9, 1·0, 1·0	33·6, 34·2	57 ,,
,,	21	0·9, 0·8, 1·1, 1·2, 0·6	33·1, 34·2	58 ,,
,,	22	1·0, 0·9, 1·1, 1·2, 1·0, 1·0, 0·9, 0·6	33, 35	59 ,,
,,	23	0·7, 0·6, 0·7, 0·9, 0·9	33, 34	47 ,,
,,	24	1·0, 1·2, 1·2, 1·2, 1·2, 0·9, 0·8	33, 34	58 ,,
,,	25	0·6, 0·8, 1·0, 0·7	33, 34	66 ,,
,,	26	0·7, 0·6, 0·7, 0·8, 0·9, 0·6	33, 33·5	58 ,,
,,	27	0·8, 0·6, 1·0, 0·7, 0·6	33, 33·5	59 ,,
,,	28	1·0, 0·5, 0·8, 1·0, 0·9	33, 34	60 ,,
,,	29	0·6, 0·6, 1·0, 1·0, 1·0, 0·8	33, 33·5	61 ,,
,,	30	0·5, 0·6, 0·6, 0·6, 0·6, 0·9, 1·0, 1·2, 1·0	33, 34	53 ,,
,,	31	1·5, 1·8, 1·8, 1·9, 0·9	33·5, 35·5	58 ,,
April	1	0·6, 0·5, 0·6, 0·6, 0·7	33, 35	60 ,,
,,	2	0·6, 0·6, 0·4	33, 33·5	60 ,,
,,	3	0·4, 0·6, 0·9, 0·8	32·5, 33·5	54 ,,
,,	4	1·0, 1·0, 0·8, 0·8, 0·6, 1·0, 0·8, 0·6	33, 34	52 ,,
,,	5	0·8, 0·6, 0·6, 1·0, 1·0, 1·0, 0·9	33, 34	56 ,,
,,	6	1·0, 1·0, 1·0, 1·2	33, 34·2	54 ,,
,,	7	0·6, 0·6, 1·0, 1·2	33, 34	47 ,,
,,	8	2·2, 2·3, 1·6, 1·0	33·5, 36	46 ,,
,,	9	0·8, 1·2, 1·2, 1·0	33·5, 34	44 ,,
,,	10	2·6, 1·2, 1·0, 1·0, 1·3, 1·2, 1·0, 0·8	33·5, 36·2	44 ,,
,,	11	0·8, 0·9, 0·8, 1·2	33, 34	46 ,,
,,	12	0·8, 0·8, 0·6, 0·6, 0·9, 1·2, 1·0	33, 34	46 ,,
,,	13	1·2, 1·0	33, 34	51 ,,
,,	14	0·8, 1·2	33, 34	47 ,,
,,	15	0·6, 0·7, 0·8	33, 34	54 ,,
,,	16	0·8, 0·6	33, 33·5	43 ,,
,,	17	2·0	33, 36	30 ,,
,,	18	3·6	36, 39	30 ,,
,,	19	4·9	39, 41	30 ,,
,,	20	5·7	41, 44	30 ,,
,,	21	..	41, 42	30 ,,

‡ The amount of running water is indicated by the time (seconds) required to fill a one-pint measure (= ·6 litre).

Although one or two of the eggs remained alive for a period of 50 days, none hatched. They showed a good appearance a few days after they were spawned, but they died off gradually.

Now this great death-rate occurred in the uncooled eggs as well as with the cooled. Some of the uncooled eggs hatched out.

The death of the eggs was not due, in my opinion, to any great extent to deficiency in the spawn itself. There are no doubt the risks of non-fertilization and slight injury which the eggs may receive when the spawn is being pressed from the fish. If the roe is quite ripe the pressure required to expel it is very slight. The extent to which these contingencies affect the eggs is not known.

Very few of the eggs escaped fertilization, if the swelling-out of the zona to form a peri-vitelline space is to be regarded as a sign that fertilization has taken place.

It is evident, however, that if there is only one micropyle by which the sperm can enter the egg, the mode in which the eggs are obtained from the fish would almost of necessity preclude a quantity of the eggs from being fertilized. The eggs flow out in a continuous ribbon, *i.e.*, each egg is in contact with an egg before and with one behind. They fall immediately on to a glass plate and adhere to it. It does not seem likely that the sperm will be able to penetrate the egg at any of its planes of contact with other eggs, or with the glass. It would follow, then, that there are several points at which the sperm may enter, or the eggs run a risk of not being fertilized. According to Jousset de Bellesme, "the robustness of an organism would depend in great measure on the number of fecundating elements which entered the egg."

In my previous paper I referred to the presence of crystals inside the zona, of the cooled eggs especially. I regarded these crystals as indicating an insufficient aeration. They are evidently excretory products which are not being properly expelled.

The crystals were prevalent during the present experiment, but they were not found in all the cooled eggs.

The death of the eggs may perhaps be ascribed in part to deficient aeration.

The uncooled eggs were in a large tank containing a sufficient supply of water. But the crowded condition of the eggs probably required some sort of strenuous movement of the plates in order to secure a continual change of the water in contact with the ova.

In the case of the cooled eggs, however, I think that neither the amount of running water nor the movement of the revolving frames was much at fault. I have no doubt that a larger current of water, and possibly a quicker movement, would be an advantage from the point of view of aeration. Death there, however, was, in my opinion, mainly due to too low a temperature. The development of the eggs was apparently arrested for a time.

May a slightly deficient aeration inhibit development without killing the egg? It is probably the case that as the embryo grows an increased aeration may become necessary.

Recommendations.

I think that it would be advisable to get the eggs, as soon as possible after spawning, into running water, or water kept in motion. The eggs are so crowded together on the plates that injury is almost certain to result from leaving the water quiescent.

During the period of incubation I believe a mechanical aeration is necessary, unless a strong current of water be available. Where the quantity of water is limited, as in the case of cooled water, mechanical aeration seems necessary.

There appears to be a risk of retarding the eggs too much by exposing them to a very low temperature.

The tank in which the eggs are kept should not be in direct contact with ice.

The Spawn.

The methods adopted for obtaining the eggs of the herring were similar to those of February 1908. I shall give a short description of each lot of eggs, and shall indicate their treatment and history.

Three lots of spawn were secured. The eggs were attached to glass plates.

The first lot, consisting of Plates 1–4, was obtained at Anstruther on February 24th, 1910. The herrings had been captured in anchored nets shot close to the harbour. The milt was coherent, and it was taken from both live and dead males. Plates 1, 2, and 4 were filled with eggs from a live female. Plate 3 received the eggs that were pressed out of a dead female. The plates were kept till next day in a herring-barrel filled with water. The water of the harbour was very dirty, and in consequence the eggs received a coating of fine sand. The spawn arrived at Aberdeen on the evening of the 25th. It was transferred to a tank (No. 2) supplied with running filtered water. Two days later the plates were put into the frame A in the cooled water. At this time the eggs looked alright, but a few were dead. Eleven days after fertilization the eggs were in the stage of the closure of the blastopore. I found no crystals in the eggs. Three days later, however, some crystals were observed. At 32 days the egg examined showed an embryo, the tail of which almost reached the head. No crystals were made out. Two days later the plates were not looking well, and on the 37th day the dead eggs were very noticeable. At 46 days some live eggs were almost ready to hatch, and they showed no crystals inside the zona On the following day a sample which was examined consisted almost entirely of dead eggs; some had died quite recently: they were still translucent.

On the 50th day the plates were removed to uncooled water. Only one live egg was found. Some of the eggs had advanced embryos. Some of the more recently dead eggs were next the glass and protected by an outer layer of eggs. The live egg, which was about ready to hatch, lived till the 58th day, but it was found dead unhatched on the 61st day. The eggs had died off steadily during the period of incubation.

Second Lot of Spawn.

The second lot of spawn was procured on 25th February from herrings which had been brought ashore in a barrel, and also from some herrings which were taken from the hold of a fishing-boat. The females were all dead; one male was alive.

Plates 6, 7, 8 were filled with spawn from the herrings of the shot. Plates 10 and 11 received the ova from the herrings brought in the barrel. They arrived at Aberdeen on the evening of the 25th and were put into tank No. 2.

Two days later Plates 6 and 10 were transferred to frame B in cooled water. The eggs looked well; a good deal of sand was present about the eggs. They showed a large blastodisc. Some of the eggs had not expanded to form a peri-vitelline space.

The next day Plate 11 was put in the cooled water. It was placed on edge in the bottom of the tank of cooled water, *e.g.*, C and D in sketch. There were some unfertilized eggs on this plate. They were small, slightly opaquish, and showed no peri-vitelline space. An irregular disorganised blastodisc was present in some cases. The fertilized eggs looked very well; they were very clean.

At 9 and 10 days after fertilization Plates 6, 10, and 11 showed a fair sprinkling of dead eggs. The live eggs were at the stage of the closure of the blastopore. There were crystals on the inside of the zona of both live and dead eggs.

On the 21st day a good proportion of the eggs was dead. Two live eggs on Plate 11 were in stages where (*a*) the blastopore was closed, or (*b*) the tail of the embryo nearly reached the head. Eggs of a similar stage of development had been found 12 days previously. During that period, viz., from March 6th to 18th, the temperature of the water was very low, often

below 1°C. It would seem in this case as if development was practically stopped at this temperature. There were lots of crystals in both live and dead eggs. Some of the eggs on Plate 6 looked very well. The zona was well distended. In the furthest advanced larva of Plate 11 no pulsation of the heart was detected.

At 52 days the eggs of Plate 11 all appeared to be dead. Some had died at the stage of the closure of the blastopore, although some had apparently died in the disc stage. I saw no embryo with pigmented eyes. The crystals were numerous inside the eggs. The eggs which were arranged singly, or in little groups of two or five, separate from other eggs, had died early. The eggs which had developed furthest were those that were shielded by other eggs. This seems to indicate that cold had been the cause of death. I did not see a live egg.

53 days.—Plates 6 and 10 had no live egg. What embryos were visible were in the stages (*a*) in which the blastopore has just closed, and (*b*) where the tail of the embryo reaches nearly to the head. None seemed to have passed the latter stage. Where the eggs are in a single layer there are many empty shells; where they are two or more layers thick, dead embryos are still present in the inside layers. Plate 6 had comparatively few eggs.

No fry hatched from Plates 6, 10, 11.

Plates 7 and 8.

On February 28, Plates 7 and 8 were put on the outside of a cubical wooden frame which was floating in tank No. 2. The frame was quite free to move about.

Eleven days after fertilization the eggs of one of the plates were in good condition, in the stage where the tail of embryo nearly reached the head. The embryo moved; the heart was beating. I could see no crystals in the eggs. Some of the eggs were dead, but they did not appear to be numerous. On the 25th day some fry were observed in tank No. 2.

26 days.—The most of the eggs were dead and covered with fungus. Some eggs had hatched out, and a few live eggs were ready to hatch. Most of the eggs seemed to have died after the blastopore had closed.

Plate 9.

This plate carried ova which were not perfectly ripe. The spawn ran out on pressure, but it was not perfectly translucent. The majority did not swell up, and did not stick well to the plate. On February 28 it was put into a metal box supplied with running unfiltered water. At that date only a few eggs remained attached. They were in good condition. One or two dead eggs were present. On the 25th day the plate was found to be covered with a thick layer of mud. Most of its small quantity of eggs was alive. The embryos were advanced; some were ready to hatch. None had apparently so far hatched. Some of the eggs had died after the embryo was formed. I made out one crystal attached to the zona.

Third Lot of Spawn.

Plates 12 to 20 were coated with spawn on the morning of February 26 by Mr. T. Smith, St. Monans. Live herrings were principally used, but the spawn was taken also from one dead fish. The plates were thickly covered all over with the ova, which in some parts were several layers deep. They were despatched to Aberdeen in a herring barrel, arriving there the same evening. The frame carrying the plates was put into tank No. 2.

Plates 12, 13, 16, 18, 20 were kept in uncooled water, while plates 14, 15, 17, 19 were put into cooled water.

Uncooled Spawn.

Two days after fertilization those of the plates which were examined looked well. The eggs were in disc stage. Where they were thickly arranged the eggs were polygonal-shaped through mutual pressure. One of the plates showed white powdery patches of excess milt, which could be brushed off. One or two dead eggs were visible. Many herring scales were attached to the eggs of one of the plates.

Plates 18 and 20 were fixed on two of the external surfaces of a cubical wooden frame, which floated freely in the tank. Plates 12 and 16 were put inside an open frame, which was anchored immediately under the inflowing current. Plate 13 was transferred to a metal box supplied with running unfiltered water. This plate at the expiry of a further 22 days was covered with a thick layer of mud. Most of the eggs had died at the stage of the closure of the blastopore. The live eggs which contained embryos ready to hatch were located at the margin of the plate, or scattered here and there on the outside of the thick layers of eggs.

10 days.—Plates 18 and 20 showed a good number of dead eggs. Live eggs were in the stages where (*a*) the tail first projects as a little process, and (*b*) where the end of the tail nearly reaches the head. No crystals were observed in the eggs. Plates 12 and 16 had a large number of dead eggs.

20 days.—On plate 20 the majority of the eggs were dead. I was able to detect only a few live eggs; they were near the margin of the plate. Many of the eggs had apparently died early.

25 days.—Plate 20 had a few eggs alive; they seemed ready to hatch. Almost all the eggs were dead.

26 days.—All the eggs of plates 12 and 16 were dead except a few round the margin. Some of the eggs had hatched.

27 days.—Plate 18 had some eggs alive; some had hatched.

34 days.—Some living unhatched eggs were found on plates 16, 18, and 20.

Plates 14, 15, 17, 19—Cooled Eggs.

Two days after fertilization certain of the plates were examined; the stage of development was that of the solid disc. The eggs all looked well On plate 19 there were some patches of milt among the eggs. They were partly brushed off.

Plates 14, 15, and 17 were put into the frame B, which was rocked till the tenth day. Thereafter it revolved.

10 days.—Plates 14, 15, and 17 showed a lot of dead eggs. The eggs stuck directly to the glass were not so bad. The live eggs, which are at the stage where the blastopore is closing or is just closed, look well. There were lots of crystals inside the eggs. Plate 15 did not show so many dead eggs. Most of the eggs were alive. Dead eggs were scattered here and there, mixed with live, among the eggs which were isolated, or in a continuous single-layered stratum, as well as where the ova were more than one layer thick. The general distribution of the dead eggs throughout the plate would suggest that they had been unfertilized, or had suffered some injury during the spawning operation. This criticism may be applied to all the lots of eggs. Numbers of minute active infusors were running about over the eggs of plates 14, 15, and 17.

The embryo has sufficient room inside the egg to float about. When the egg is rotated the embryo, under the influence of gravity, alters its position and comes to rest again.

20 days.—Live eggs were visible all over plate 14. One showed the tail as a little process. Crystals were seen in both live and dead eggs, but not in all the eggs examined.

38 days.—A dozen eggs taken off one of these plates included three live eggs. The heart was beating slowly. The eyes were beginning to show ome black pigment. One egg exhibited the condition where the tail nearly reaches the head. I saw no crystals inside the zona.

44 days.—Of 38 dead eggs, 19 contained embryos; of the embryos, 7 had pigmented eyes.

50 days.—The cooling ceased on this date; no larva had hatched out. The plates were transferred to tank No. 2.

52 and 53 days.—No live egg was found. Some eggs had died in the disc stage, but great numbers have embryos of greater or less size. A good number of the eggs next the glass where the ova have been two or more layers thick had died in the disc stage.

None of the eggs of these plates had hatched.

Plate 19.

4 days.—The eggs looked very well.

8 days.—The eggs were alright; some at the margin were dead.

9 days.—This plate did not show many dead eggs; it was in better condition than those in frame B.

12 days.—Some dead eggs were noticed.

20 days.—There was a large quantity of eggs dead. The live eggs were found all over the plate; the dead eggs were massed in the central region, where there are also a few live eggs. The dead eggs were mainly where the eggs were two layers deep. In one case some eggs on top were dead, while those next the glass were alive. Some eggs showed a fairly long tail, which did not, however, reach to the head. I could see crystals in some eggs, none in others.

28 days—The majority of the eggs were dead, but numbers were still alive; one was in the stage similar to that found 8 days previously. Numerous infusors were running over the live eggs.

51 days.—I did not notice a single live egg. On one part of the plate where the eggs formed an uniform single-layered stratum completely covering the portion, I found that the dead eggs had been pretty well developed. Inside a high heap the eggs had died early when the embryo was forming. The eggs were well covered in parts with sporozoan colonies and fungus.

IV.—ON THE FOOD OF THE HALIBUT, WITH NOTES ON THE FOOD OF *SCORPÆNA*, *PHYCIS BLENNOIDES*, THE GARPIKE AND *CHIMÆRA MONSTROSA*. By THOMAS SCOTT, LL.D., F.L.S.

The stomachs of over one thousand specimens of halibut, *Hippoglossus vulgaris* (Flem.), have been examined during the period from September 1909 to June 1910. The sizes of the halibut ranged from 18 inches to 5 feet in length. They were captured in various parts of the North Sea and North Atlantic, and landed at the Aberdeen Fishmarket, and I desire to acknowledge my indebtedness to the fish merchants there who so kindly supplied the material for this research, and for the data concerning the sizes of the specimens supplied.

It has been my experience, as it is the experience of others when engaged in a research of this kind, that even under the most favourable conditions a certain percentage of the fishes examined have either no food in their stomachs, or it is so much broken up and decomposed by the action of the gastric fluid—an action that does not cease till some time after the death of the fish—as to be indistinguishable.

Of the halibut stomachs examined, about one-third, or nearly 34 per cent., were found to be empty, or the nature of the food could not be determined, which leaves about seven hundred, the contents of which could in some measure at least be identified.

THE FISHES.

A large proportion of the food observed consisted of Gadoids, chiefly haddocks and whitings; Norway pout (*Gadus esmarkii*) were also met with on several occasions. On the other hand, codfish and brassies were rarely noticed. Flat fishes, such as long rough dabs, were sometimes obtained, but not very often, and once or twice a lemon sole and witch soles occurred.

THE CRUSTACEA.

Crustacea were tolerably frequent, especially in the stomachs of the smaller halibut, but they also occurred in those of the larger examples. In the case of some of the larger halibut it was apparent that little effort had been exerted to crush the crustaceans found in their stomachs; specimens, almost complete, of tolerably large crabs like *Geryon tridens*, *Lithodes maia* and *Munida bamffica*, their carapace only being somewhat softened by partial digestion, being present. Small crabs like *Hyas coarctatus* and *Atelecyclus septemdentatus*, but especially the former, were by no means rare, several of them being scarcely injured except that the shell was slightly softened. Norway lobsters (*Nephrops norvegicus*) were frequent, both in the stomachs of large and small fishes, full-grown as well as young specimens being moderately frequent, and not a few of the smaller as well as the larger examples having apparently been swallowed whole, only the shell being slightly softened and shrivelled. *Nephrops* and hermit crabs—especially *Eupagurus bernhardus*—were the more common among the crustacea observed.

Mollusca.

With the exception of one or two species of Cephalopoda, Mollusca were rarely met with, the only species of shell-fish observed being *Fusus antiquus*, which occurred on one or two occasions; the halibut did not apparently take the whole shell, but simply snapped off the extended head as far as it reached beyond the protecting shell. The operculum of one *Fusus*—a large specimen—taken thus unawares, measures across the longest diameter 60 millimetres by about 33 millimetres at the widest part. But though shell-fish were rare, Cephalopods were tolerably frequent, though sometimes the brown horny jaws were all that was left to represent the cuttlefish—the soft body having rapidly succumbed to the solvent action of the gastric fluid. In several cases, however, fairly complete specimens were obtained, showing that the cuttlefish had been swallowed whole, the body first, with the tentacles streaming behind, as was apparent from the position of the organism in the stomach. The cuttlefishes observed belonged to three, or perhaps four genera, viz., *Loligo*, *Eledone* (and probably *Octopus*), and *Ommatostrephes*. The *Eledone* and *Octopus* are Octopods—that is, they are provided with eight tentacles; they differ in the *Eledone* having tentacles with a single row of suckers and the *Octopus* with a double row—the suckers of the one row alternating with those of the other. This, which is one of the more obvious differences between the two, is in the case of a partly digested specimen somewhat difficult to make out. The specimens, however, which were sufficiently perfect for identification were found to be *Eledones*—probably *Eledone cirrcosa*. Several specimens of *Loligo* were observed, but with the exception of perhaps one or two, they all belonged to *Loligo vulgaris* (Lamarck). None of them appeared to be full grown, and the shell (or bone) of the largest specimen measured only $7\frac{7}{8}$ inches (about 20 centimetres) in length, and $1\frac{3}{8}$ inches (3·5 centimetres) in width at the widest part. The shell of a smaller specimen was rather narrower in proportion to the length; this one measured fully $4\frac{1}{4}$ inches (110 mm.) by $\frac{5}{8}$ of an inch (16 mm.) in width. *Ommatostrephes* was represented by a piece of the anterior end of the shell (or bone) of a specimen of moderate size.

The Echinodermata.

The Echinodermata were only sparingly represented by fragments of *Spatangus* and a nearly complete but crushed specimen of *Cidaris papillata*. The discs and arms of a few Ophiurids were also observed, but these were probably derived from the stomachs of Gadoids which the halibut had swallowed.

The Annelids.

Traces of Annelids (*Chætopods*) were observed in a few stomachs, but these, like the Ophiurids mentioned above, may have come from the stomach of a fish swallowed by the halibut.

Table shewing Number of Fishes Examined.

The following is a tabulated summary of the total number of stomachs examined each month, the number containing food that could be identified, and the number empty, or the contents of which could not be determined:—

[Table.

Months when the Stomachs were examined.	Total number of Stomachs examined each month.	Number with food that could be identified.	Number empty, or with food that could not be determined.
September 1909	21 stomachs	12 stomachs	9 empty
October ,,	115 ,,	74 ,,	41 ,,
November ,,	101 ,,	53 ,,	48 ,,
December ,,	167 ,,	117 ,,	50 ,,
January 1910	91 ,,	59 ,,	32 ,,
February ,,	160 ,,	125 ,,	35 ,,
March ,,	83 ,,	68 ,,	15 ,,
April ,,	124 ,,	84 ,,	40 ,,
May ,,	95 ,,	60 ,,	35 ,,
June ,,	119 ,,	62 ,,	57 ,,
Totals for the ten months.	1076 ,,	714 ,,	362 ,,

It will be observed from the preceding table that the total number of halibut stomachs examined was 1076, and of these 362 (about 33·7 per cent.) were empty, or the nature of the contents could not be determined, while the remaining 714 contained food which consisted of organisms that could at least to some extent be identified.

It will also be observed that during the several months the proportion of empty stomachs differed sometimes considerably; this difference, however, may not be due to natural causes. Sometimes it could be explained by the fact that some of the stomachs available for examination were those of "welled fish"—fish which had been on the ship for a number of days, and kept alive in a tank fitted up for the purpose in the ship's hold; any food, therefore, the stomach may have contained would be more or less completely digested by the time they were brought to the market. Sometimes also the food may have consisted of only soft-bodied organisms, such as cuttlefishes, which are quickly reduced to unrecognisable pulp; in other cases, the only evidence that the fish had recently been feeding was the presence in the intestine of partially eroded otoliths, or other less digestible substances.

In comparing the food contents of the stomachs examined from month to month, slight differences in the constituents of the food have also been observed. For a while crustacea, especially such forms as hermit crabs (*Eupagurus*) and *Nephrops*, were of frequent occurrence, but in the latter months, *i.e.*, from March onwards, crustacea have not been so often met with; while on the other hand, Gadoids, such as haddocks and whitings, but other fishes as well, have constituted the principal part of the food, and sometimes was the only kind observed.

In the following summarised statement a description of the food observed in the stomachs during each of the ten months from September 1909 to June 1910 inclusive, is given.

September 1909.

Twenty-one halibut stomachs were examined in September, and of these 12 contained food that could be identified. The food in one of them consisted of fragments of *Spatangus purpurea* and *Fusus*, that of another consisted of starfish discs and arms. In a third the food consisted of remains of fish and a Decapod crustacean, while the contents of the others consisted entirely of fishes, among which were the remains of haddocks and whitings and a fairly large herring.

October.

The stomachs examined in October numbered 115, and 74 of these contained food. The length of the halibut examined ranged from 20 to 50 inches, but only a few were over 36 inches in length, and the food contents of the larger did not differ in any marked degree from those of the smaller examples. The contents of between fifty and sixty of the stomachs consisted for the most part of crustacea or of fish. Small cuttlefishes constituted the food of about half-a-dozen stomachs, but in the remainder the contents were mixed crustacea and fish, with sometimes a small cuttlefish. The fishes that could be distinguished by their earstones or otherwise were chiefly Gadoids (haddock and whiting) and herrings; the remains of a few flat-fishes were also observed, but the species could not be determined.

The crustacea consisted largely of *Nephrops norvegica*, *Munida bamffica*, and *Eupagurus bernhardus*; several of the *Nephrops* were large, full-grown specimens, measuring over all 8 inches to fully 9 inches in length. In one of the stomachs examined twenty-one specimens of *Munida*, large and small, were counted; in another a nearly complete *Geryon tridens* occurred, but the shell bore evidence of the solvent power of the gastric fluid; while in a third a tolerably large soft-shelled female *Lithodes* was obtained. A few specimens of *Hyas coarctatus* and *Portunus* sp. were met with, while in one stomach, containing a mixed lot of food, the contents consisted of *Nephrops*, small fishes, and a number of tolerably large isopod parasites, *Cirolana borealis*, which are not uncommon on Gadoids in the North Sea, and are described by G. O. Sars as being among the most effective scavengers of the sea, and also as doing injury to the fishes caught on the fishermen's lines when not quickly removed.

November.

The number of stomachs examined in November was 101, and of these 53 contained food. Most of the halibut ranged from two to three feet in length, but four or five of them measured four feet in length and three five feet.

Crustacea (*Portunus*, *Atelecyclus septemdentatus*, *Eupagurus* sp., *Nephrops*, and *Munida*), together with young fishes, formed the principal portion of the food of smaller halibuts, but the food of the larger individuals consisted chiefly of fishes. In the stomach of one of these larger examples the earstone of a tolerably large hake was obtained; the earstone measured 25 mm., and the fish it belonged to could not, therefore, have been less than about 22 or 23 inches in length. For the purpose of comparison, it may be stated that the length of the earstones of a hake 16 inches long measure nearly 17 mm., and those of one 14½ inches 16 mm.* Other fishes observed included a whiting 11 inches long, partly digested; a tolerably large codling, remains of haddocks, a few long rough dabs, and sand-eels. One stomach contained five small flat-fishes, the jaws of a cuttlefish, remains of *Nephrops*, and a few parasitic *Cirolana borealis*. Another was full of hermit crabs (probably *Eupagurus bernhardus*), while a third contained six or seven specimens of *Munida bamffica* and a small stone. Seventeen of the stomachs contained fish only, 13 contained crustacea only, and the contents of other ten consisted of a mixed lot of crustacea and fish, including also the remains of small cuttlefishes; while the food contents of three consisted of cuttlefishes only.

December.

The number of stomachs examined in December was 167, and 117 of these contained food that could to some extent be identified. With the exception of eleven, the food observed in these stomachs consisted entirely either of

**Twenty-fourth Ann. Rept., Part III.*, p. 66 (1906).

fishes (Gadoids chiefly) or of crustacea (chiefly *Eupagurus bernhardus*, but one or two other species of *Eupagurus*, *Nephrops*, etc., were also occasionally present). The stomachs containing crustacea only, numbered about 65, and those containing fish only, numbered about 43. In eight halibut stomachs the food contents included a whiting and one or two small shell-fish. Another contained the remains of four or five *Munida bamffica* and a small cuttlefish (*Eledone*), while a third contained *Nephrops* and *Gadus* (?) *esmarkii*. The entire contents of one stomach consisted of cuttlefish, one contained Annelids only, and one part of a large *Fusus antiquus*.

The Gadoids met with most frequently consisted for the most part of haddocks and whitings, a few of which were of fairly large size and measured 10, 11, and 12 inches in length. The remains of herrings were also occasionally noticed; one stomach contained a herring 9 inches long and a fairly large cuttlefish—*Loligo vulgaris*. Another contained a herring about 7 inches long, which was sufficiently perfect to show that it had been feeding largely on the Schizopod *Thysanoessa neglecta* before being captured by the halibut.

Among the crustacea observed, the hermit crab (*Eupagurus bernhardus*) was, as stated above, the more common form, but one or two specimens of *Eupagurus pubescens* and *Eupagurus cuanensis* also occurred. The few *Portuni* observed were limited to *P. holasatus* and *P. depurator*. Two of the stomachs examined in December contained each a specimen of *Geryon tridens*, and one or two small *Atelecyclus* were also noticed.

Differences in the Food of Large and Small Fishes.

The only appreciable difference that could be observed in the food of the larger halibut was that fishes appeared to be more frequently consumed, while the smaller preyed more upon crustacea.

The stomachs examined in December were, for the most part, from halibut three feet in length, and only a few from specimens over that size.

January 1910.

In January 1910, 91 halibut stomachs were examined, and 59 of these contained food that could be identified; none of the halibut were over three feet in length. The food contained in 31 of the stomachs consisted entirely of fishes, 19 contained crustacea only, while in the remaining 11 the food consisted partly of fish, partly of crustacea, and also occasionally with the remains of small cuttlefish.

Fishes.

The fishes observed belonged, for the most part, to the Gadoids, chiefly haddocks and whitings, some of which were of tolerable size. In one stomach the remains of two haddocks between 10 and 11 inches long were observed, and a whiting 14 inches in length occurred in another, while in a third there were two specimens of a coal-fish partly digested, the length of which would be about 12 to 15 inches, but these were rather exceptional occurrences. Other fishes observed included one or two Brassies, a few Norway pouts, and the remains of what appeared to be a lemon sole, but the fish was too much digested to be satisfactorily identified; sand-eels were also frequently met with in the stomachs of the smaller halibuts. In the stomach of one of these I found a Pogge (*Agonus cataphractus*), 4½ inches long and nearly perfect, its hard scaly covering being nearly impervious to the solvent action of the the gastric fluid.

CRUSTACEA.

The crustacea most frequently observed were *Nephrops norvegicus*, hermit crabs, chiefly *Eupagurus bernhardus*, *Portunus depurator*, and one or two other species such as *Corystes cassivelaunus*, *Hyas coarctatus*, small *Galathea* sp., and *Pandalus montagui*. In one stomach no fewer than a dozen small *Corystes cassivelaunus* were counted, while some of the *Nephrops* and hermit crabs observed were of fairly large size.

CUTTLEFISHES.

Cuttlefishes were rarely met with in the stomachs examined in January, and those observed appeared to be *Eledones*. No Annelids nor starfishes were observed.

February.

The number of halibut stomachs examined in February was 160, and of these 125 contained food; the others were empty, or their contents could not be identified.

A considerable proportion of the halibut were small, being under 3 feet in length, and only a few of them were from 3 to 3½ feet long.

Fishes—Gadoids and sand-eels for the most part—formed the only food observed in nearly sixty per cent. of these, and the stomachs in which crustacea alone constituted the food contents amounted only to a little over nine per cent. On the other hand, the number that contained a mixture of crustacea, fish, and other organisms was larger in proportion than in the previous months. Cuttlefishes were also much more frequently met with.

FISHES.

As indicated above, the fishes observed consisted chiefly of whitings, haddocks, and sand-eels, several of the former being tolerably large. One of the stomachs, for example, contained a fairly large haddock 18 inches long and a small one 8 or 9 inches; another stomach contained two whiting, and, judging by the size of their earstones, both were at least 15 inches long. The occurrence of such large specimens was, however, exceptional; the sizes of haddock and whiting more commonly noticed ranged from about 7 to 10 inches. Most of the sand-eels were only half-grown specimens, but a few were adults, or nearly so, and were full of ripe or nearly ripe spawn. Other fishes which were observed, though somewhat sparingly, included brassies and *Gadus* (?) *esmarkii*, long rough dabs, small plaice, and the remains of herring.

CRUSTACEA.

The crustacea comprised such forms as *Eupagurus bernhardus*, and *Eupagurus prideaux*, *Nephrops norvegicus*, *Hyas coarctatus*, *Portunus holsatus*, *Crangon almanni*, and the leg of a fairly large *Lithodes maia*, as well as the digested remains of *Lernæa branchialis* and other nondescript forms. A number of Schizopods (*Thysanoessa*) and *Euthemisto compressa* were also observed, but these were doubtless from the stomachs of some of the fishes swallowed by the halibut.

CUTTLEFISHES.

Cuttlefishes occurred in no fewer than about 20 of the stomachs examined in February, and in about 13 of these they formed the only organisms present. The only species that could be determined were *Loligo vulgaris* and *Eledone cirrosa*, the remains being usually too imperfect for identification.

March.

In March 1910, 83 stomachs of halibut were examined, and of these 68 contained food which could in some measure be determined, and, as in the previous month, this food consisted largely of fishes; crustacea were only sparingly met with, and very few cuttlefish were observed. The following proportions will show the nature of the food contents in the stomachs examined:—Fish remains only were found in 59 stomachs; crustacea only in 1; mixed fish, crustacea, cuttlefish, etc., in 9; and cuttlefish only in 1.

Fishes.

The fishes observed were, as before, chiefly Gadoids and sand-eels. The only Gadoids satisfactorily determined were, for the most part, haddocks, whitings, *Gadus esmarkii*, and a three-bearded rockling (*Motella tricirrata*). Some of the haddocks and whiting were tolerably large fishes. One of the latter measured about 15 or 16 inches long (its earstones were 24 mm. in length), and one of the halibut about four and a half feet long was found to have swallowed a whiting about 14 inches in length, and two haddocks, one of which would be about 18 inches and the other $14\frac{1}{2}$ inches (their earstones measured respectively 20 mm., 18·5 mm., 16 mm.). Such large fish, were, however, rather exceptional; smaller examples, ranging from 7 to 10 inches long, were more frequent. Specimens of what appeared to be *Gadus esmarkii* were observed on several occasions, but only the one specimen of *Motella tricirrata* was noticed.

Sand-eels, a few tolerably large, measuring from 7 or 8 inches, were not infrequent, and in one stomach the remains of twelve of them were found. There occurred in one of the halibut stomachs a small portion of the vertebra of an apparently large Gadoid; one of the joints measured across the long diameter 22 mm. and 19 mm. vertically (these measurements were made immediately after the specimen was removed from the stomach and before drying). The remains of herring were also observed, but they were of rare occurrence.

Crustacea.

The infrequency of crustacea in the halibut stomachs examined during March, when compared with some of the previous months, was somewhat marked. The species observed included *Portunus* sp., *Eupagurus bernhardus*, *Crangon allmanni*, *Galathea* sp., etc. In the stomach of one of the larger halibut a nearly complete female *Lithodes maia*, loaded with spawn, was obtained, the shell, claws, and legs of which were quite soft.

Cuttlefish.

The contents of several stomachs consisted not only of fish and crustacea, but also sometimes of small cuttlefishes; the only specimens that in some measure could be determined were Octopods, apparently belonging to *Eledone* (*E. cirrosa*). In the stomach of a moderately large halibut were found the remains of a fairly large cuttlefish, but the only part that could be utilised for identification was a fragment of the anterior end of the "shell," which apparently was that of an *Ommatostrephes*, the shell of which is entirely different from that of any of the more common British cuttlefishes.

April.

The number of halibut stomachs examined in April was 124; 40 of these were found to be empty, or their contents could not be identified, while the food in the remaining 84 was more or less recognisable.

Small and medium sized fishes, chiefly Gadoids, appeared to be the food mostly sought after by the halibut, and fully 60 of the stomachs examined contained nothing else. Crustacea, on the other hand, were only sparingly met with, and were usually associated with other kinds of food, such as small fishes, but cuttlefish remains were also occasionally present.

Fishes.

Fishes, as stated above, formed the principal part of the food of the halibut examined in April; haddocks and whitings were the species most commonly met with, and, though they were usually comparatively small, moderately large specimens were also occasionally obtained; generally, however, they were so much broken up by the digestive fluid that the accurate measurement of the fish itself was impracticable, but as the earstones were frequently found to be uninjured, a careful measurement of these always afforded a fairly correct indication of the size of the fish they belonged to. Their reliability as a guide to the approximate size of the fish has been frequently tested in the case of such species of haddocks, whiting, codfish, and some other Gadoids, and generally with satisfactory results.*

Three fishes, all haddocks, were found in one of the halibut stomachs examined in April; their earstones measured 18 mm., 17 mm., 16 mm., showing that the first two were from 16 to 17 inches in length, and the third about 14 inches. In another stomach a whiting about 14 inches long and two haddocks about 17 or 18 inches respectively were observed, and the earstones of these three fishes measured—the whiting 20 mm., the larger haddock 18·5 mm., and the smaller 16 mm.; while in a third stomach, viz., that of a halibut over four feet long, were found the remains of a haddock over 18 inches in length (earstones 21 mm.), a moderately large flat-fish, the species of which was doubtful, and the jaws of a cuttlefish, probably an *Eledone.* Among other fishes met with in the stomachs examined in April were a few Norway pouts, *Gadus esmarkii*, a lemon sole, *Pleuronectes microcephalus*, the remains of a moderately large flat-fish that appeared to be a witch sole, *Pleuronectes cynoglossus,* and measured about 12 inches long, a considerable number of sand-eels, a smelt, *Osmerus eperlanus*, about nine inches long, a herring about 10½ inches long, and remains of others, and also a young piked dog-fish, *Acanthias vuglaris*, of moderate size; in this specimen the spine in front of the first dorsal fin measured from the base of the exposed (coloured) part to the tip about 20 mm.

Crustacea.

Crustacea were not very plentiful in the stomachs examined in April, and those met with were usually associated with other forms. The species observed were chiefly *Hyas coarctatus*, *Portunus* sp., hermit crabs (*Eupagurus bernhardus*), and *Nephrops.*

Cuttlefishes.

Cuttlefishes, or their remains in the form of dark horn-coloured jaws, were met with on several occasions. They all appeared to belong to the eight-armed group Octopoda, and those of them sufficiently perfect for identification were all apparently *Eledones.* Some of them were tolerably large, but accurate measurements were hardly attainable, as the delicate extremities of the tentacles were usually wanting, besides being otherwise injured. One that was tolerably perfect gave the following measurements:—Body to base of tentacles, 5¾ inches; length of tentacles, or at least what remained of

* *Cf.* "Observations on the Otoliths of some Teleostean Fishes." *Twenty-fourth Annual Report of the Fishery Board for Scotland*, Part III., p. 48-82, Pls. I.-IV.

them, 6 inches. This *Eledone*, therefore, would have measured over all fully 12 inches in length—a fairly big mouthful to swallow even for a moderate-sized halibut.

Cetera.

Some odd things observed included *Crangon allmanni*, discs of starfishes (Ophiura), small *Echinocardium*, fragments of Zoophytes, a small univalve shell (*Fusus*), and a few small stones. Most of these small things, however, were probably derived from the stomachs of the haddocks, whitings, &c., which the halibuts had swallowed.

May.

The number of halibut stomachs examined in May was 95, and of these 60 contained food which could, to some extent at least, be identified. The size of the halibut from which these stomachs were removed ranged for the most part from 30 inches to 42 inches in length. A few were from halibut under 30 inches, and a few others between 48 and 60 inches. The food found in 54 of the stomachs examined consisted entirely of fishes, chiefly Gadoids. Two contained crustacea only, and two the remains of cuttlefish only, while in two others were found the remains of fishes and shell-fish (*Buccinum*, sp.). From the results stated above, it would appear that in May halibut had been feeding more exclusively on fishes than during any of the previous monthly periods. Whether there is any natural cause for this change—whether, for example, it is due to seasonal influences affecting the supply of food, or merely to some accidental change—there is scarcely sufficient data to show.

The Fishes Observed.

The fishes met with in the halibut stomachs examined in May included, as usual, haddocks, whitings, sand-eels, and very rarely flat-fishes. Herrings were occasionally observed, a few of which were of fairly large size. In one stomach, for example, a herring of about 10 inches in length, and in another a specimen about 8 inches, were obtained. A witch sole about 12½ inches long was also found in one of the stomachs examined on May 6th. Some of the Gadoids were tolerably large; a whiting 15 inches long and a brassie (*Gadus luscus*) 13 inches were among some of the larger specimens met with.

The fish food in a considerable number of the stomachs examined in May was so much digested that if the earstones were absent the species was practically unrecognisable.

Crustacea, Cuttlefishes, &c.

Crustacea and cuttlefishes were both very sparingly met with. *Hyas coarctatus* was almost the only crustacean observed, and the cuttlefish remains consisted chiefly of their dark-coloured horny jaws.

June.

The halibut stomachs examined in June numbered 119. Fifty-seven of them were empty or contained food that could not be identified, while the food in the remaining 62 consisted largely of gadoids. In 47 of the stomachs examined the food consisted entirely of fishes, and in fully 50 per cent. of them the food was so much digested that in many cases only a few bones were left, so that even the species could not be determined. The following Gadoids were recognised, viz.:—The remains of a codfish about 15 inches in

length, and another between 9 and 10 inches; the latter had a small flat-fish of doubtful species in its stomach. Haddocks were observed in seven or eight halibut stomachs, and whitings in about the same number. A *Gadus* (?) *luscus* about 9 inches long occurred in one stomach, and *Gadus esmarkii* in several. A few both of the haddocks and whitings were apparently tolerably large. The remains of fairly large herrings were also observed in three stomachs, and a small flat-fish—species doubtful—in one.

Crustacea.

In ten of the stomachs examined in June, the food consisted entirely of Crustacea. *Hyas coarctatus*, the most common species, occurred in seven of them. The hermit crabs (*Eupagurus bernhardus* and *Eu. prideaux*) were only observed on one or two occasions, while Norway lobsters (*Nephrops*), so frequent during some of the previous months, were apparently entirely absent; so also were several of the other species met with during the winter.

Cuttlefishes.

Cuttlefishes were rarely met with in the halibut stomachs examined in June, and those observed were the remains of either small *Eledone* or *Octopus*.

Echinoderms.

A specimen of *Cidarus papillata*—a partly crushed test without spines—was obtained in one of the halibut stomachs examined in June.

Having in the preceding notes given a short descriptive account of the food-contents of the halibut stomachs examined from month to month from September 1909 to June 1910 inclusive, it may be useful if the various organisms referred to are brought together in the form of a more or less systematic list, as follows:—

A Systematic List of the Fishes, Crustacea, and other Things Mentioned in the Preceding Notes as Constituting the Food of the Halibut.

Food of the Halibut.

Classified List of Organisms mentioned in the preceding Notes.

Fishes.

Agonus cataphractus, Linné. The pogge.
A nearly perfect specimen, about $4\frac{1}{2}$ inches long, obtained in January.

Gadus callarius, Linné. Codfish.
Remains of a moderately large codling observed in stomach of large halibut in November.

Gadus æglefinus, Linné. Haddock.
Of frequent occurrence; some of the specimens tolerably large.

Gadus merlangus, Linné, Whiting.
Of frequent occurrence; some of the specimens tolerably large.

Gadus pollachius, Linné. Pollack or lythe.

Gadus virens, Linné. Coal-fish or saith.
Specimens that belonged to one or other of these two species have been occasionally observed, too imperfect to be satisfactorily identified.

Gadus luscus, Linné. The bib.

Gadus minutus, Linné. The poor or power-cod.

Specimens belonging to one or other of these Gadoids were occasionally met with, too imperfect to be satisfactorily determined. Their earstones are somewhat short and massive.

Merluccius vulgaris, Cav. The hake.

The earstone and other remains of a hake was found in the stomach of a tolerably large halibut in November. The hake would be between 15 and 16 inches long.

Molua molva, Linné. The ling.

A small ling, about 13 inches long, was obtained in a halibut's stomach in November.

Motella (*Onos*) *tricirrata*, Bloch. Three-bearded rockling.

A specimen of this species was observed in a halibut's stomach in March.

Ammodytes (*?*) *lanceolatus*, Le Sauv. Sand-eel or sand-launce.

Sometimes fairly common, especially in the stomachs of the smaller halibut.

Drepanopsetta platessoides, Fabr. Long rough dab.

A few examples, sufficiently perfect for identification, and measuring 5 to 6 inches in length, were obtained in November and January.

Pleuronectes platessa, Linné. Plaice.

Observed on two occasions, one specimen about 8 inches long in February, and another about 6½ inches in April.

Pleuronectes microcephalus, Don. Lemon dab or lemon sole.

Observed on two occasions; one specimen, length doubtful, in January, and one about 10½ inches long in April.

Pleuronectes cynoglossus, Linné. Witch sole.

A specimen about 12½ inches long was obtained in a halibut's stomach in May. The remains of what appeared to be another occurred in April, but too imperfect to be satisfactorily determined.

Pleuronectes limanda, Linné. Dab or common dab.

Only a single specimen observed.

Osmerus eperlanus, Linné. The smelt.

One specimen observed in a halibut's stomach in April.

Clupea harengus. Herring.

Herrings ranging in length from 7 to 10 inches were obtained in about a dozen of the halibuts' stomachs examined. A few of them appeared to have been feeding on *Thysanoessa* before being captured by the halibut.

Acanthias vulgaris. Spur-dog, piked dog-fish.

A young specimen from a halibut's stomach in April; the coloured part of the spine in front of the first dorsal fin measured from base to tip about 20 millimetres.

Crustacea.

Hyas coarctatus, Leach.

Observed on various occasions; specimens usually small.

Portunus depurator, Leach.

Sparingly met with on several occasions.

Portunus holsatus, Fabr.

Obtained only in three or four of the stomachs examined.

Portunus pusillus, Leach.

Obtained once in January along with *Hyas coarctatus*.

Portunus arcuatus, Leach.
Very rare in stomachs examined in January.

Atelecyclus septemdentatus, Mont.
This species occurred sparingly on one or two occasions.

Corystes cassivelaunus, Pennant.
This also occurred sparingly, but on one occasion a dozen small specimens in a stomach in January.

Lithodes maia, Linné.
Three small, fairly perfect specimens were obtained in a stomach examined in October, and a larger female carrying eggs, but with the shell soft and somewhat damaged, in one examined in February.

Geryon tridens, Kroyer.
A fairly large specimen of *Geryon* was found in one of the stomachs examined in October, and two smaller specimens in those examined in December.

Eupagurus bernhardus, Linné.
Tolerably frequent, especially in the winter months.

Eupagurus prideaux, Leach.
Obtained sparingly on two or three occasions.

Eupagurus cuanensis, Thomps.
Rare in one or two stomachs in December.

Eupagurus pubescens, Kroyer.
Fragments apparently belonging to this species occurred sparingly on one or two occasions in December.

Galathea sp.
Rarely met with, and only young or imperfect specimens.

Munida bamffica, Pennant.
Munida was not infrequent during the winter months. In one of the stomachs examined in October, 21 specimens, large and small—mostly small—were obtained, and 6 in another.

Nephrops norvegicus, Linné.
This crustacean was moderately common, especially during the winter months, not a few of the specimens being apparently adult; some of them measured 8 to full 9 inches to the end of the claws.

Crangon allmanni, Kinahan.
Rare, and probably derived from the stomachs of fish swallowed by the halibut.

Pandulus montagui, Leach.
Rare; observed only on one or two occasions.

Thysanoessa neglecta, Kroyer.

Euthemisto compressa, Goes.
Both of the species named were doubtless derived from the stomachs of sand-eels and herrings swallowed by the halibuts.

Cirolana borealis, Lilljeborg.
Several specimens were met with in one of the stomachs examined in October, probably having been swallowed with the Gadoids to which they were adhering as parasites.

Lernœa branchialis, Linné.
Fragments were observed on one or two occasions, having doubtless been fixed on the gills of Gadoids swallowed by the halibut.

Mollusca.

Fusus antiquus, Linné.
Two stomachs contained each an *operculum* only; another contained the head (with *operculum* attached) of a tolerably large specimen.

Ommatostrephes todarus, Delle Chiaje.

A small fragment of a cuttlefish shell, apparently belonging to this species, was obtained in a halibut stomach examined in March.

Loligo vulgaris, Lamarck.

Several specimens of *Loligo* have been met with, and though they may not all belong to the species named, one or two certainly do so.

Eledone cirrosa, Lamarck.

Specimens of *Eledone* were met with on several occasions, but other specimens were obtained which were scarcely perfect enough to determine the species. Cuttlefish jaws were also not uncommon, representing both large and small specimens.

Echinodermata.

Spatangus purpureus, O. F. Müller.

Fragments of the test of a *Spatangus* occurred in the intestine of one of the halibuts examined in September.

Cidarus papillata, Leske.

A partly-crushed test was obtained in a halibut's stomach examined in June.

Ophiura sp.

Several discs and fragments of arms were observed from time to time, but not identified.

Cetera.

Annelida were met with on one or two occasions, but appeared to be exceedingly rare in the stomachs of the halibut examined. Fragments of Zoophytes were also occasionally observed, and so also were small bits of stone. One piece of stone measured in millimetres 27 by 21 by 13, and its weight just under half an ounce avoirdupois.

Notes on the Food of *Scorpæna dactyloptera*, *Belone vulgaris*, *Phycis blennoides*, and *Chimæra monstrosa*.

Scorpæna dactyloptera, De la Roche.

A considerable number of *Scorpæna dactyloptera* were examined in February and March 1910, but the stomachs of about two-thirds of them contained nothing that could be satisfactorily determined. In one of the stomachs of the remainder was found a nearly perfect specimen of *Sepiola rondeleti*, Leach, and in another a small individual somewhat imperfect, which appeared to belong to the same species. Cuttlefish remains were found in other four, but were too imperfect to be satisfactorily identified, though from their appearance they were probably also *Sepiolas*. In the stomach of another of the same lot of *Scorpænas* were fragments of *Crangon*, apparently *C. allmanni*.

The Garfish or Sea Pike (*Belone vulgaris*, Cuvier).

A number of garfish captured in the North Sea, off the Aberdeenshire coast, in April and May, were found to have been feeding more or less extensively on small crustacea ; both the stomach and intestine were in some instances filled with them. Eight tolerably large garfish, about 18 to 20

inches in length, had their stomachs filled with almost nothing else than pelagic Amphipods, which appeared to belong to *Parathemisto oblivia*, with a few fragments of some specimens belonging to the *Euphausiadæ*, probably *Thysanoessa*. Everything the stomach contained, however, was so fragmentary that the species to which they belonged could not with certainty be determined. No other organisms besides those mentioned were observed.

Phycis blennoides (Brun)—The Greater Fork-beard.

Stomachs, containing food, of about a dozen examples of the greater fork-beard (*Phycis blennoides*) from the Fish Market at Aberdeen were examined in February and the beginning of March 1910. They nearly all contained the partly-digested remains of small fishes, chiefly Gadoids. Though none of the specimens were perfect enough for satisfactory identification, it is probable that most of them belonged to *Gadus esmarkii*, as the form and structure of their ear-stones appeared to be practically identical with those of that species. In one stomach ten pairs of ear-stones were counted; three of the pairs were those of fishes about six inches long, while the others belonged to fishes of smaller size. One stomach contained a young piked dog-fish about 4 inches (100 mm.) in length, and another, a small lump-sucker (*Cyclopterus lumpus*). The crustacea were represented in these stomachs by *Nephrops norvegicus*, *Crangon* sp., *Pandalus montagui*, *Pandalina brevirostris*, and *Nyctiphanes*; there were also remains of crustacea that could not be identified. The only other organism observed was a small cuttlefish, probably an *Eledone*, but scarcely perfect enough to be satisfactorily determined.

Chimæra monstrosa.

In January 1910 a number of specimens of *Chimæra monstrosa* from the Fish Market were examined, and the food contained in their stomachs was found to consist of various organisms, comprising shell-fish, crustacea, Annelids, and Echinoderms.

Shell-fish.

The shell-fish included *Pecten tigrinus*, *Anomia* (?) *ephippium*, small *Fusus* sp., small *Buccinum undatum*, *Cardium fasciatum*, and *Scalaria* sp.

Crustacea.

The crustacea comprised Decapods, such as *Ebalia* sp., small *Hyas coarctatus*, small *Eupagurus*, and Amphipods, such as *Hippomedon denticulatus* and *Ampelisca* sp.

Annelids.

Several fragments of Annelids occurred, but the species could not be made out.

Echinoderms.

The only species of Echinoderm identified was *Echinocardium cordatum*; the remains consisted of spines and fragments of tests.

V.—BACTERIOLOGICAL INVESTIGATION AS TO THE CAUSE OF AN OUTBREAK OF DISEASE AMONGST THE FISH AT THE MARINE LABORATORY, BAY OF NIGG, ABERDEEN. By A. G. ANDERSON, M.D., D.Sc., D.PH., M.A.

About the end of August 1908, some haddocks and whitings were required for replenishing the tanks at the Marine Laboratory at the Bay of Nigg, Aberdeen, where for the previous eighteen months I had been carrying out some experimental work on the decomposition of fish and its detection from the public health point of view. This work has been already published by the Fishery Board for Scotland in their *Twenty-sixth Annual Report* (*Part III.*)—*Scientific Investigations.*

On the evening of the 21st August some were caught about a quarter mile from the shore in six fathoms of water and about 200 yards from the mouth of the a sewer. The fish were conveyed to the Laboratory in two large galvanized tin boxes and placed in two of the tanks at the Marine Station, amongst other haddocks and whitings which had been in the same tanks for about nine months, and which had been caught three to four miles from the shore. The attendant officer at the Laboratory, who was in charge of the operations in catching and conveying the fish to the tanks, states that he distinctly observed a few spots on some of the fish which attracted his attention. Some of the spots were small and pale in colour, about the size of a threepenny piece; others were larger, reddish-looking, and about the size of a crown piece. These appearances he observed in four or five of the fishes. During the second night after being placed in the tanks, one of the haddocks died; and the disease was observed to be spreading. In the case of those previously showing small affected areas, the areas were now seen to be getting larger and redder; while the rest of the fish not already affected, and including those recently caught and those previously in the tank, now began to show small spots in the initial stage, which were paling and desquamating. The spots were not limited to any particular area, although most common on the neck, back, and tail. By the third day many of the fish showed sluggish movements and a few more died. By the fifth day all the fish in these tanks were dead. The number of haddocks and of whitings in separate tanks previous to introduction of those caught on 21st August is given as probably 25 of each, and those introduced about one dozen each.

APPEARANCE OF THE ULCERS.

On examination of the fish after death the ulcers were seen not to be localised to any one part of the body, but irregularly distributed on the neck, back, tail, and on the fins. They varied in size from one to four or five millimetres in diameter, and were of the spreading and sloughing type. The base of the ulcer was depressed, often reaching down to the muscular tissue in the more advanced ulcers, and usually showing some necrosed and sloughing tissue with some grumous pus. The edges were inflamed, irregular and ragged, and very much undermined. The surrounding tissues in the more advanced ulcers were soft and œdematous. In five of the fish examined the base presented a slightly injected appearance, with apparently some attempt at reaction on the part of the tissues against the attacking micro-organisms; but in no case did the ulcer appear to be passing into the condition of healing with the formation of true granulation tissue. In many

of the fish, when the ulceration was not so advanced, and where there was no loss of continuity of tissue, small greyish-white spots were seen, where the scales were falling off, and rubbed off very readily, while the tissues beneath were very red and congested.

Bacteriological Examination.

Four of the fish, two haddocks and two whitings, were removed in sea-water tanks to Marischal College. While the fish were still alive scrapings were made from the ulcers by means of sterilised platinum wire and plated out on gelatine, Agar and fish-agar media, and incubated at 20°C. and 37°C. respectively.

Smears were also made on glass slides from the ulcerated areas.

The fish were then opened by abdominal section under sterile conditions. Then cultures and smears were made from both the peritoneal fluid and heart blood by sterilised platinum wire. Streak cultures were also made of the peritoneal fluid on Digralski and Conradi media.

Microscopical Examination of the Smears.

Smears from the Ulcerated Areas.

These were stained with the ordinary basic aniline dyes—Methylene Blue, Dilute Carbol Fuchsin, Gram's Stain, etc. All these preparations showed the presence of cocci which were strongly Gram positive; also some rod-shaped and many vibrio-like micro-organisms, which in hanging drop preparations were actively motile.

Blood Smears.

These were treated precisely as the last, and in two of the fish examined the blood showed the presence of cocci, which were strongly Gram positive.

Smears from the Peritoneal Fluid.

These, when treated as the above and examined, did not show the presence of any micro-organisms.

Examination of Cultures.

Cultures from Ulcerated Areas.

The gelatine plates were examined 48 hours after inoculation. Many small colonies of a brownish-yellow tint were seen in the media, and around these liquefaction of the media was just seen to be commencing. Also a smaller number of bluish-white colonies around which there was no liquefaction of media. The Agar plates were also examined 48 hours after inoculation. Numerous colonies of a dirty whitish colour with a yellowish to orange tint were seen. There were also present a few large superficial colonies, and a few deep colonies of a brownish-white colour.

From these different colonies, sub-cultures were made on the following media :—

Gelatine tubes—Streak and shake cultures.
Agar tubes—Streak cultures.
Litmus peptone milk.
Bouillon.
Potatoes,

and incubated at 20°C. and 37°C. respectively.

The yellowish to orange-coloured colonies gave the following results :—

In the gelatine stab cultures a thin streak of growth was visible after 24 hours, and by 36 hours liquefaction of the gelatine was seen commencing round the growth on the upper surface of the tube. Liquefaction proceeded rapidly, and the growth gradually fell to the bottom of the tube as a flocculent deposit, and appearing of a bright yellow colour.

The stroke cultures on the Agar tubes showed an abundant shiny opaque growth in 24 hours, generally passing from a faint orange to a yellowish colour.

Litmus Peptone Milk.—This medium was turned acid, shown by the disappearance of the blue colour and appearance of red colour. The milk was also distinctly coagulated.

Bouillon.—In this medium there appeared at first a uniform turbidity which gradually settled to the bottom of the tube, showing a yellowish tint.

Potato Medium.—In 48 hours there was an abundant growth of a distinctly orange colour.

Microscopical Examination of Sub-cultures.

They all showed the presence of cocci varying from $\cdot 7\mu$ to $\cdot 9\mu$ in diameter, spherical in shape, and the growths occurred in irregular groups or masses. The cocci were strongly gram positive, and stained with all the ordinary basic aniline dyes. These cocci exhibited all the essential biological, cultural, and microscopic characters of the staphlococcus pyogenes aureus.

Examination of the Sub-cultures of other Colonies.

These were all examined after 48 hours' growth.

Gelatine Stab Cultures—Thin, whitish streak of growth; no liquefaction of gelatine, and after 8 days a few bubbles of gas in the media.

Agar Stroke Cultures—A thin whitish-opaque line of growth.

Litmus Milk—Medium turned acid and milk clotted.

Bouillon—Slight turbidity.

Potatoes—A thin film of growth, moist-looking, and of brownish tint.

Microscopic Examination.

These colonies were seen to be short, rod-shaped bacilli, varying from $0{\cdot}3\mu$ to $0{\cdot}7\mu$ in diameter. They stained with basic dyes, but very readily decolorised by Gram's stain.

Hanging drop preparations were then made, and the bacilli were found to be motile, with generally a slow rotatory motion.

The following media were then inoculated and incubated at 37°C. :—

I. MacConkey's Bile Salt Glucose Peptone Litmus Solution.
II. Drigalski and Conradi's Nutrose Litmus Agar.
III. Neutral-Red Bile Salt Agar.

After 48 hours' growth :—

I. Showed the presence of acid and gas.
II. Numerous red colonies.
III. Numerous red colonies colouring the surrounding medium red, and producing a characteristic haze.

From the colonies on media II. and III. sub-cultures were made on the following media and incubated at 37°C. :—

A. Glucose Neutral Red Broth.
B. Lactose Peptone Litmus Solution.
C. Peptone Water.
D. Litmus Milk.

After 48 hours A. showed greenish-yellow Fluorescence . . FL.
After 48 hours B. ,, Acid and Gas . . . . AG.
After 6 days C. ,, Indol production . . . . IN.
After 4 days D. ,, Acid and Clot . . . . AC.

By the above method I followed Houston's "Flaginac" basis of classification for Bacillus Coli. When these tests are positive, the Bacillus Coli is typical or indistinguishable from the typical Bacillus Coli of the human intestine. If some of the tests are negative, or not well marked, then the bacillus is considered atypical. Consequently the bacilli found were of the type Bacillus Coli Communis.

Blood Cultures.

In three of the fish examined, growths of colonies appeared in the Agar tubes. When these were stained and examined they were found to be pure growths of cocci, and gave the essential tests for the staphlococcus pyogenes aureus.

Peritoneal Fluid Cultures.

These were all negative.

Sections

Besides pursuing the ordinary methods, I also adopted the method of preparation and staining of sections which was first introduced by Levaditi, and described by him in the "Annales de Institut Pasteur," January 1906. Levaditi and many others who were working with him found great difficulty in differentiating the Spirochæta Pallida in sections by means of the ordinary stains, and devised the following method which was adopted here with the hope that the vibrio-like micro-organisms, which were seen in all the smear preparations made from the ulcers while the fish were still alive, might be exhibited, if present, in sections of the tissues.

Method.

(1) Small blocks of tissue were cut out through the ulcers about 1 mm. thick, and fixed in 10 per cent. Formol for 24 hours.

(2) Then washed and hardened in 96 per cent. Alcohol for 24 hours.

(3) Washed in Aq. dest. for some minutes until the fragments fell to the bottom.

(4) The blocks were then impregnated at 38°C. for 5 days in 2 per cent. silver nitrate.

(5) Washed for a few minutes in Aq. dest. and reduced in the following mixture at room temperature from 24 to 48 hours:—

Ac. pyrogallic,	..	..	4 per cent.
Formol, ..	..	..	5 cc.
Aq. dest. ..	..	..	100 cc.

(6) Washed in water, dehydrated in alcohol xylol, paraffin sections.

(7) Some sections were mounted in xylol and Canada balsam, and some were further treated by—

(*a*) Giemsa's Solution.

(*b*) Toluidin Blue (method of Manourlian).

On examination the ulcers presented the appearance as already described. The floor of the deeper ulcers extended down to the muscular tissue. Small irregular masses of cocci were present in all, and were very numerous in most of the preparations—especially in the subcutaneous tissues and at the spreading margins. The cocci stain very readily with Ag. when precipitated in the metallic state.

Neither by any of these methods of preparation and examination of sections, nor in any of the preparations from the culture media, were the vibrio-like micro-organisms found, although they were undoubtedly present

in the original ulcers, and seen in the smear preparations and in the hanging drop preparations, in which they were actively motile.

After the death of the haddocks and whitings in the tanks, the tanks were emptied and cleaned out, but the water they contained was inadvertently allowed to get into an outside pond in which there were about 150 plaice.

In the beginning of September 1908, 193 plaice arrived from the Moray Firth, and, on being placed in the pond amongst the other plaice, it was then discovered that 58 of the 150 plaice in the pond were dead, and were removed. On the 23rd October, 267 more plaice arrived from the Moray Firth and were placed in the pond; and it was shortly after that date when 129 more dead plaice were discovered and removed from the pond. On the 27th November, 284 more plaice were received from the Moray Firth and placed in the pond, and up to 26th December 1908, 13 more dead plaice had been removed. That is, during four months 200 plaice have died in this pond.

The fish from the Moray Firth, on careful examination, showed no evidence of any disease.

After frequently examining these fish, I could come to no other conclusion than that they were suffering from the same disease as that which appeared in the case of the haddocks and whitings. The superficial ulcers were of the spreading and sloughing type, and presented precisely the same characters as already described in the former fish. They showed the same irregular distribution on neck, back, and tail, but were very seldom seen on the ventral surface. They commenced in paling and desquamating spots, and spreading rapidly to form large ulcerated areas, often one to two inches in diameter. The edges of the ulcers were deeply undermined, the base often extending down to the muscular tissue and covered with broken-down tissue. But here the base of the ulcers often presented a very injected appearance, and there appeared to be a decidedly stronger reaction on the part of the tissues against the invading micro-organisms than what appeared in the case of the haddocks and whitings. This may be due to a better blood supply in the case of the plaice, which on the whole are hardier fish than the round edible fish such as haddocks and whitings; and although difficult to state definitely, yet there has to be kept in view the probability of variation both in the direction of diminution of the virulence of the attacking micro-organisms, and also in the powers of resistance of these different classes of fish.

Bacteriological Examination.

Two of the plaice were conveyed to Marischal College while still alive, and a bacteriological examination made precisely in every detail as in the case of the haddocks and whitings. Hence I will not repeat the various processes, but state the results.

From all the lesions examined by smear and hanging-drop preparations, rod-shaped and vibrio-like micro-organisms were present. Cocci were also present and strongly Gram positive.

From both fish, by the methods already described, typical Bacillus Coli were isolated by means of cultural media and subjected to the same confirmatory tests.

From the blood pure cultures of cocci were obtained. These were subjected to the usual tests for the staphlococcus pyogenes aureus.

The cultures from the peritoneal fluid were again negative.

Sections were made as already described. These showed the same appearance as in the case of the haddocks and whitings.

Again, in none of the cultural preparations nor in sections did the vibrio-like organisms appear which were always seen in smear preparations made from the lesions while the fish were alive.

Provisional Conclusion.

In reviewing the above work, the micro-organisms found present were :—

I. Vibrio-like bodies in all the superficial lesions, but which were not found in any of the cultures, nor in sections.

II. Micro-cocci; chiefly staphlococcus pyogenes aureus in all the superficial lesions examined, and in the blood in most cases in pure culture.

III. The Bacillus Coli Communis in the superficial lesions and also in cultures from these.

Consequently, since these micro-organisms are so closely identified with sewage, it is difficult to avoid the conclusion that the fish had died from some form of septicæmic poisoning, and possibly caused by infection from these sewage-borne micro-organisms.

How Infection may Take Place.

Johnston, Fisheries Laboratory, Liverpool, informs me that a few years ago he observed at Port Erin a similar epidemic, and that the signs and progress of the disease was very similar to that which I have described in this paper. A large number of the plaice impounded in the spawning pond died rapidly from some apparently infectious disease. He came to the conclusion that the disease was due to a fungus, and that it was probably conveyed to the fish by means of insects, of which large numbers floated about on the surface of the pond.

Johnston also informs me that he has frequently observed how readily superficial ulceration follows in fish which have received the slightest external injury, even from trivial surface lesions produced when caught in the trawls.

Then, as marine fish approach inshore they must become more liable, through various causes, to receive small superficial abrasions, which may be just sufficient to allow micro-organisms to find a lodgment; and that this will more readily occur in the neighbourhood of sewer outlets into the sea has frequently been observed by M'Intosh and others, who have noted the remarkable influence which such outlets have in attracting fish to such areas.

Thus, while infection by contact in the open sea is possible, there is greater opportunity for such to take place inshore, especially in the vicinity of sewage outlets, and much more so when the fish are confined in tanks.

On the other hand, although it appears that fish may be very susceptible to external microbal attacks through superficial lesions, it appears that they can swallow great numbers of bacteria with apparent impunity.

Many fish feed directly on sewage when available, and especially many of the crustacea, the smaller and often microscopic forms of which, such as the Copepoda, may be said to act as the scavengers of the sea shore. They feed almost entirely on sewage, and are present in vast numbers, and in their turn they become one of the chief sources of the food supply for the larger fish.

Further, we know that fresh-water fish must swallow large numbers of bacteria in so many sewage-polluted streams.

Again, in an article on the "Decomposition of Fish and its Detection," which appeared in the *Twenty-sixth Annual Report of the Fishery Board for Scotland*, I pointed out that marine fish which were caught near the shore or the mouths of inland rivers, or near the discharge of sewage effluents, contained large numbers of bacteria of the sewage type, and which were readily isolated from the intestinal contents, whereas in proportion to the distance out at sea at which the fish are caught the bacteria decreased; and in fish caught far out at sea, or in a sewage-free locality, very few such micro-organisms could be detected. These results were generally in accordance with those of Houston, and in close agreement with those of Eyre.

Still, I am not aware that either marine, inshore, estuarine, or inland fresh water fish suffer in any appreciable way from the ingestion of sewage bacteria. But it has to be admitted that, although we now have Hofer's "Fischkrankheiten" as the only published treatise dealing with the diseases of fresh-water fish; as regards the diseases of marine fish very little has been done and still less written. Certainly, in my own experimental work on both marine and fresh-water fish, I have never found any lesion which I could attribute to the ingestion of bacteria into the alimentary canal, although this does not exclude the possibilities of the effects of bacterial toxins; nor in any case in which the peritoneal fluid was examined were bacteria of the intestinal type discovered when the fish were living and in a healthy condition.

In this respect, however, the evidence given by Professor Herdman before the Royal Commission on Sewage Disposal is both interesting and important. While his evidence is in general agreement with the above conclusions, he further stated that, although he had never known of a case of a fish being poisoned by a pathogenic micro-organism, and was of opinion that even if fish were to ingest sewage bacteria in large quantities they would probably show no intestinal lesions, yet at the same time there was the possibility that the bacteria, through their toxins, might cause a lowering of the vitality of the fish. This statement is, of course, an expression of the general mode of action of all bacteria—they may cause local lesions or act through their toxins or by both combined. Herdman, however, makes some differentiations which are not only important from the bacteriological, but also from the point of view of public health. He distinguishes between Pisces or swimming fish and the Mollusca and Crustaceans or shell fish, and considers that in the case of the latter or shell-fish, even although we have as yet no evidence that they suffer in themselves from the ingestion of pathogenic bacteria, yet, since they are so frequently used as articles of food in the raw condition, and consequently often proved to be the medium of transmission of disease, any sewage pollution as regards such fish should be prevented.

As regards the Pisces or swimming fish, this danger is not present to the same extent; and in any case such fish are usually cooked, and when properly cooked any such danger of the transmission of pathogenic bacteria is practically precluded.

Regarding susceptibility, Herdman is of opinion that marine fish are not so susceptible to microbal attacks as fresh-water fish; and that amongst the former there are degrees of susceptibility, inasmuch as flat-fish are probably less susceptible or show greater resistance to bacterial attacks than round fish, such as haddocks and whitings.

Of the first proposition I have no experimental evidence; but regarding the second, certainly my own observations on the reactions of the flat-fish and round-fish respectively to the bacteria, which were the cause of this outbreak of disease, and which forms the subject of this investigation, appear to bear out this statement; and it may be added that in all cases young fish are more susceptible to bacterial poisoning than adult fish.

Recently a great deal of valuable scientific work, on the question of standards for tidal waters in relation to offensive putrefaction and injury to fish, has been accomplished by Dr. Letts of Belfast and Dr. Adeney of Dublin; and as these workers have approached the subject purely from the general and chemical points of view, their conclusions are of great interest and importance, when studied along with the bacteriological aspect of the question.

One of their conclusions, and with which Herdman agrees, has a direct interest, when read in conjunction with the subject of this paper, namely, that, while the discharge of sewage into any river, estuary, or sea-board is in such quantity that its dilution with fresh or sea water is sufficiently large

as not to cause any physical clogging of the gills of the fish, and as to ensure an adequate supply of dissolved oxygen for purposes of respiration, such sewage may have no harmful effect on the fish inhabiting any such areas.

To sum up, it may be said that, although on the one hand the evidence appears to indicate that fish do not suffer readily from the ingestion of bacteria, nor from the presence of sewage in the medium in which they are living, so long as its dilution is sufficient to prevent clogging of the gills, and sufficient to provide an adequate supply of dissolved oxygen for purposes of respiration, yet it further appears from the evidence of this investigation that such occurrences as outbreaks of disease amongst fish due to the presence of sewage-borne micro-organisms is a possibility of some significance to Health Authorities in whose sanitary areas sewage is being deposited in rivers, estuaries, or on to the sea-shore. As a corollary the above conclusions further serve to emphasise the importance of the possibility of the transmission of disease by fish inhabiting sewage-polluted areas, and more especially by shell-fish, whose peculiar constitution, mode of life, feeding, and texture render them specially liable to harbour pathogenic bacteria.

In conclusion, I wish to avail myself of this opportunity of expressing my indebtedness to Dr. T. W. Fulton, Scientific Superintendent, for the facilities and assistance which I have readily received while working in the Marine Laboratory.

VI.—NOTES ON THE EGGS OF THE ANGLER (*LOPHIUS PISCATORIUS*), HALIBUT (*HIPPOGLOSSUS VULGARIS*), CONGER VULGARIS, AND TUSK (*BROSMIUS BROSME*); A YOUNG ARNOGLOSSUS, *sp.*; ABNORMALITIES IN LOPHIUS, GADUS, RAIA; DISEASES IN GADUS, PLEURONECTES, ONOS, ZOARCES; OCCURRENCE OF *HIMANTOLOPHUS RHEINHARDTI*, AND *CLUPEA PILCHARDUS*; THE EFFECTIVENESS OF A SEINE-TRAWL IN A SMALL POND. By H. Chas. Williamson, M.A., D.Sc., F.R.S.E., Marine Laboratory, Aberdeen.

(Plates II.-VI.)

CONTENTS.

The Larvæ of the Angler (*Lophius piscatorius*).

The larvæ of the American *Lophius piscatorius* have been described by Agassiz,* and those of the British example by Prince.†

An opportunity occurred in July, 1907, of studying the larvæ of this fish. A large mass of the spawn was sent in a herring-barrel to the Laboratory by Mr. Caird, Sandhaven. It arrived on the 15th July. Many of the eggs were alive when the mass was transferred to a tank of sea-water.

The embryos, which were black, were already moving about inside the eggs. The oil globule was also pigmented black. The general appearance of the embryo did not seem to indicate that it was in a very advanced stage of development; the tail of the embryo was very short. As was pointed out by Prince, the short tail only partially encircles the yolk when the embryo is ready to emerge.

* *Proc. Amer. Acad. Sci.*, 1882.

† "Notes on the Development of Angler Fish (*Lophius piscatorius*)," 9th *Annual Report of the Fishery Board for Scotland*, for 1890, Pt. III., p. 343, 1891.

Some of the larvæ had hatched out by 17th July. One is shown in fig. 2, Pl. II. After preservation in formaline it measured 5·5 mm. in total length. The head-end of the larva is very black. The oil globule has a large amount of black pigment associated with it. The pectoral and pelvic fins are short and rounded. The first head filament is seen as a thick papilla rising from the hind region of the head.

In a specimen examined five days later (fig. 10), two of the head filaments are visible. The young form, after preservation in formaline, was 6 mm. long. The anterior filament is already long; the posterior one is very short. The pelvic fin is now much elongated, and is a narrow process.

Another which was taken from the tank on 24th July, *i.e.*, seven days after the larvæ were first noticed, possessed three head filaments (fig. 9). In formaline it measured 8 mm. in length. The pelvic fin had increased in size; a small angle at the base of the fin indicates the rudiment of the second branch. The yolk was much reduced in quantity, but there was still some present. The eyes of the little fish when alive were blue.

On 29th September, *i.e.*, about ten weeks after the arrival of the eggs, the sole remaining larva was examined (fig. 6). It measured, when preserved, 9 mm. in length. The three head filaments were rather longer than in the stage just described. The pelvic fin had further increased in length; it was now about half the length of the fish. It had, moreover, a short second branch.

I obtained a young *Lophius piscatorius* in Loch Fyne, near Otter, in a tow-net worked horizontally about 5 fms. below the surface on 28th July, 1899. It is shown enlarged in fig. 17. It seemed to be still in the larval condition, although I was not able to make out whether there was still yolk present or not. It was examined after preservation in alcohol. It was quite black, except for its colourless marginal fin, and the colourless sub-epidermal spaces on the head. The tail was twisted, and that prevented an exact measurement of its length. It was then about 7 mm. in length. The operculum (*operc.*) was comparatively large. The pelvic fin was a single branch, with a broadened base. Only two head filaments were present. A parasite (*p.*) was adhering to the anal marginal fin.

The sketches here given illustrate stages which differ slightly from those described by Prince. The drawings of Agassiz have been reproduced in "Scandinavian Fishes," and also by Gill.* They also differ in details from the present material. In the latter the second branch of the pelvic fin was only visible in the last described stage, whereas it was a long branch in one of Agassiz's figures, which, judged by the size of the head filaments, would be near that of my fig. 9. Prince's larva of the fifteenth day approximates the condition shown in fig. 6. He describes the histological structure of the embryo and of the larvæ of one, nine, and fifteen days. A post-larval form, 7 mm. in length, was described by M'Intosh and Prince.† The changes between the advanced larva described by Prince and this post-larva are inconsiderable.

The head filaments are much further back in the larva than they are in the adult. In the latter the first filament occupies a position close to the upper lip. The head filaments are supplied from the last cranial nerve (*vagus*). The branches to the filaments run forward over the top of the skull

A sample of the spawn of this fish was obtained on June 25th, 1908, five miles east of Loch Bracadale, Skye, by Mr. Alex. Mitchell, Lossiemouth. Mr Mitchell, who had attended the class for fishermen at the Laboratory, preserved a portion of the spawn and forwarded it to me. It seems probable that the spawn of this form may not always reach the surface.

* "The Life-history of the Angler." *Smithsonian Miscellaneous Collections*, No. 1569. Washington, 1905.

† "Development and Life-histories of Teleostean Food and other Fishes." Trans. Roy. Socy. Edinburgh, Vol. xxxv., Pt. iii., 1890.

The Ripe Eggs of the Halibut (*Hippoglossus vulgaris*), Flem.

The ripe eggs of the Halibut have been obtained on two occasions from the fish-curing yard of Mr. Angus, Aberdeen.

Holt and M'Intosh have described the ripe eggs of this form, and little remains to add to their descriptions. I have, however, made out what I regard as a second investment to the egg. In addition to the zona which is so prominently cross-hatched with short intersecting lines (*z.*, fig. 8), there is a delicate vitelline membrane closely investing the yolk. This was seen crumpled in one of the eggs (*vt.*, fig. 7).

On 25th January a roe was obtained which had some clear eggs in it. The fish had been caught by a trawler 145 miles E.N.E. of Aberdeen in 65 fms. Some of the ripe eggs were measured in sea water. They varied from 2·75 to 3.2 mm. in diameter. Some of the ripe eggs were not yet free from the follicle. Two of these measured 2·7 and 3 mm. respectively. Some white opaque eggs measured 1·8 to 2 mm. in diameter. This is probably the maximum size of the white yolked egg.

A running halibut was observed by Mr. R. Thompson, at Aberdeen, on March 1. It measured 175 cm. in length, and had been captured by a steam liner on the West side of Scotland, viz., Flannan Islands, 12–13 miles W. by N. ½ N.

Another fish which measured 4 feet 3 inches (127 cm.) in length was ripe on March 2.

On May 2 a quantity of ripe ova was sent to the Laboratory in a small box. The halibut from which the eggs had been taken was described afterwards as being about 4½ feet (130 cm.) in length. It was believed to have been caught on the Viking Bank, between Shetland and Norway. The eggs formed a fluid mass, but they were quite free from one another. They were quite translucent and showed no oil globule. They measured from 3 to 3·35 mm. in diameter.

M'Intosh had examined the ripe eggs taken from a halibut caught about 150 miles E.N.E. from Peterhead in April. The present records extend the spawning period for the northern part of the North Sea to five months, viz., January to May.

The Eggs of Conger vulgaris.

All the specimens of this species here dealt with were kindly supplied by Mr. Eunson, fish merchant, Aberdeen.

Two Congers measuring 6 feet 1 inch (180 cm.) and 6 feet 3 inches (185 cm.) were examined on 13th November, 1908. The ovaries were very large, filling a large portion of the abdominal cavity in both. Eggs were issuing in a small quantity from the genital aperture. That circumstance was probably due to the rough treatment to which the fishes had been exposed. The eggs were white, opaque, and measured from ·47 mm. to ·65 mm. in diameter. An albuminous fluid exuded from the aperture with the eggs. It coagulated in sea water, binding the eggs together in a translucent matrix. In an hour or two afterwards the mucous had dissolved, setting free the ova. The eggs showed only a trace of a separation of the zona from the yolk. After preservation in formaline, some of the eggs showed a fairly wide peri-vitelline space.

In view of the fact that Cunningham* found that the ripening congers were undergoing a process of degeneration, attention was paid to the bodily structure. Both fishes were dark-coloured. One especially was black all over except for the belly, which was a little lighter in colour than the rest of the body. The second specimen had a dark-slate dorsum, with a light-slate-coloured ventrum.

* "Marketable Marine Fishes." London, 1896.

Parts of the fishes were left in a tub without any preservative, and two days later they were surrounded by a large quantity of watery fluid which had been derived from them. The fishes, although fat and full of flesh, seemed on arrival to be in a jelly condition. The skull was not soft, but there was a mass of jelly-like substance on top of it. The bones cut fairly easily, but the backbone of a conger 34 inches (85 cm.) long, which had a very small ovary, also cut fairly easily.

On October 30, a conger 4 feet 7 inches (140 cm.) long had large ovaries containing eggs which measured ·6, ·55 × ·62 mm. in diameter. Some eggs and a portion of the ovary were pressed out at the genital aperture. The eggs were white. After being in sea-water for two days a slight separation of the zona from the yolk was seen both in the free eggs and also in some of those attached to the portion of the ovary.

Three congers were obtained on November 2nd. The largest, which was 5 feet 2½ inches (156 cm.) long, had a large ovary, the eggs of which measured ·6, ·55 × ·6 mm. in diameter. As in the fishes recorded above, the eggs were opaque white. After being in sea water overnight three eggs which had been pressed out by the genital aperture showed a slight separation of the zona from the yolk. No translucent large eggs were visible in the ovary. The fish was in very good condition.

Two smaller congers, 3 feet 7½ inches (109 cm.) and 3 feet 10½ inches (126 cm.), had small ovaries in which the largest eggs measured ·12 and ·15 mm. respectively. The eggs were translucent.

The bones of the skull, and of the vertebral column of the largest fish, were more easily cut through with a knife than the corresponding bones in one of the smaller fishes. The largest fish was very black on the dorsum, while the smaller fishes had a slate-coloured back.

Two other specimens were obtained on November 4. They measured 4 feet (120 cm.) and 4 feet 2 inches (125 cm.) respectively. In both the eggs measured ·15 mm. in diameter. The smaller fish was of a light-slate colour, with the edge of the marginal fin black. The snout was not so rounded, nor did the eyes appear so large, as in the large specimens just recorded. The flesh was not jelly-like. The skull was difficult to cut through, but the vertebral column was easily cut across.

On December 8, a black jelly conger was examined. It was very fat. It measured 5 feet 6½ inches (165 cm.) in length. A piece of the ovary had been pressed out at the genital aperture. The eggs were opaque white, and measured ·4–·55 mm. in diameter. Another fish which was received on December 24 was examined after it had been in formaline. The ovaries were developing. The largest yolked eggs were ·4 mm. in diameter.

In February, seven congers measuring from 3 feet 3 inches (97 cm.) to 4 feet 5 inches (132 cm.) in length were examined. They had all small ovaries. The eggs observed in two specimens were ·17 and ·2 mm. respectively in diameter.

Five fishes were obtained in March. They measured from 3 feet 1½ inches (93 cm.) to 4 feet 3½ inches (128 cm.). The smallest fish had ova ·1 mm. in diameter, while two, measuring 4 feet 1 inch and 4 feet 3½ inches, had eggs ·25 mm. in diameter. These eggs were visible to the naked eye.

In April, a specimen 5 feet 6 inches (165 cm.) had white yolked eggs measuring from ·25 to ·5 mm. in diameter. This fish was thick and in good condition.

One conger was dissected in May. It was 4 feet 3¼ inches (128 cm.) long. The eggs were whitish, and measured ·15 mm. in diameter.

Two examples obtained on July 11 measured 2 feet 7 inches (77 cm.) and 4 feet 1 inch (122 cm.). The eggs measured ·12 mm. and ·2 mm. in diameter respectively.

In August, six congers measuring from 3 feet 1½ inch (93 cm.) to 4 feet 3 inches (127 cm.) were examined. The eggs varied from ·12 to ·17 mm. in diameter.

Two congers examined in September measured 4 feet 4½ inches (131 cm.) and 4 feet 5¾ inches (134 cm.) respectively. The larger specimen was the darker in colour, and its flesh was not so firm as that of the small fish. The ovary of the latter was small; the eggs were white and measured ·22 mm. in diameter. The larger fish had large ovaries, the eggs in which varied from ·25 to ·55 mm. in diameter.

The largest eggs obtained from the conger by Cunningham were opaque white and measured 1·0 mm. in diameter.

Eigenmann* has provisionally described a pelagic egg which was obtained in the waters of the United States as that of *Conger vulgaris.* The egg measured 2·4–2·75 mm. in diameter, and was "very closely related to No. 6 of the Muræenoid eggs of Raffaele."

The Eggs of the Tusk (Brosmius brosme).

Some fertilized eggs of the Tusk were sent by Mr. Duthie, Fishery Officer, Lerwick. They arrived on 12th May, 1905, and were examined next day. A number were alive and floating. They measured 1·2 mm. (1), 1·22 mm. (3), 1·25 mm. (14), 1·27 mm. (7), 1·3 mm. (1). The oil globule measured ·25 mm. in diameter. The stage of development was early, viz., blastodisc stage, with the segmentation (or germinal) cavity formed (fig. 51). The oil globule had a bronze colour. The development of this form has been minutely described by M'Intosh,† and, so far as my own observations go, they confirm that zoologist's description. As M'Intosh pointed out, the zona is creased, and the oil globule may move freely through the yolk. On May 15th, of six eggs taken at random, four showed the segmentation cavity stage; the remaining two had the embryo half round the yolk, or a little further on. The dorsum of the embryo was covered with minute black pigment spots. The temperature of the water on this date was 12·1° C.

An embryo observed on May 16th had a great quantity of black spots dorsally on the head, body, and tail, but massed mainly over the abdominal region. There was a lumen in the gut, and the heart was visible, although not yet beating. There was only black pigment present, and it was all dorsal in distribution.

On May 18th one embryo completely encircled the yolk. Large round black pigment spots were scattered over the dorsum of the whole fish. The heart was beating. The oil globule was still large. The temperature of the water was 12·6° C.

May 22—Some eggs were found to have hatched to-day. In the larva the oil globule is posterior, and is of a bright bronze colour. There are brown-black bars on the little fish—viz., one on the head, a small one on the pectoral region, and a large bar about one-third of the distance between the anus and end of the tail. A jet-black patch on the tail is very marked. The pigment on the trunk is fairly scattered, and stellate in some cases. There are black pigment spots on the ventral half of the body posterior to the anus, showing a slight concentration midway between the anus and the large black bar of pigment. The eye is not black.

On May 26th the larva had the following naked-eye appearance:—It showed five black bars across its body. The big black eyes and black pigment on top of the head form the first bar. The second bar is a big black patch on the dorsum over the hind half of the yolk-sac. The third, fourth, and fifth bars are on the post-anal body. No. 3 is a jet-black patch at about one-third of the length of the post-anal body. The fifth is a big

* "The Age and Development of the Conger Eel." *Contributions from the Biological Laboratory of the U.S. Fish Commission, Woods Hole, Mass.* Bulletin for 1901, pp. 37–44.

† "On the Eggs of the Tusk." *Tenth Annual Report of the Fishery Board for Scotland* for 1891, Pt. III., p. 288. 1892.

jet-black patch on the base of the caudal fin. The fourth is a lighter and smaller bar situated midway between the third and fifth. The yolk-sac is long, and elliptical in shape. The bronze or golden oil globule is posterior. There was still a considerable quantity of yolk present.

On May 29th all the larvæ were dead.

A Post-larval Arnoglossus (Figs. 14 and 16).

The little fish, which was captured by the *Garland* at the mouth of the Clyde, between Sanda and Brennan Head, on 12th September, 1899, is shown enlarged in fig. 14. The tow-nets were being worked at 15 and 20 fathoms. The specimen is a little injured. It is symmetrical; the two eyes occupy practically identical positions on opposite sides.

In greatest length it measured 9 mm.; it was 4 mm. in greatest breadth. The number of rays in the dorsal fin was 79+, and in the anal fin 56+. The fin-rays were not clearly separated off in the posterior part of the dorsal marginal fin, nor at either end of the anal marginal fin. The fin-rays are formed of a number of longitudinal strands. The vertebræ were made out to be about 39; they were counted by aid of the muscle segments. One tooth was made out on each side in the upper and lower jaws.

The most noteworthy feature of the little fish was the presence on the forehead of two very long delicate filaments. These filaments were jointed, and proved to be the two halves of the "single cephalic" tentacle. Gunther* described and figured certain larval Pleuronectids which were obtained by the *Challenger* Expedition off Sierra Leone. They measured 6 and 7 mm. in length, and they had the long frontal filament. They evidently belong to the genus *Arnoglossus.* The possession of this tentacle characterises, as Raffaele and Ehrenbaum showed, the early stages of *Arnoglossus.* An enlarged drawing of the top of the head of this example is given in fig. 16. A little posterior to the first ray (1) there is a second (2), which is larger and stouter than the ray that succeeds it. It is not clear whether this ray is shorn of its natural length. It is injured, but whether shortened or not I did not make out. It is not like the next succeeding rays (*fn.*), split into many fine strands. It appears to have a different character from them.

The top of the head is furnished with short needle-like spines on either side of the beginning of the dorsal fin, and coming down for a little distance on the right side of the skull. Ehrenbaum† has described several young individuals of this genus. Lately the question of the descrimination of the species of these larvæ has been treated by Petersen.‡ I have not been able to satisfy myself as to the specific identity of the specimen just recorded.

A Rare Angler—*Himantolophus Reinhardtii*, Lütken. (Figs. 22, 27, 28).

A specimen of this fish was landed at Aberdeen in March 1908, by a trawler which had captured it in Icelandic waters. It was courteously presented by Mr. Eunson. It was preserved in formaline for some time before being examined.

It is jet-black in colour, on the ventrum as well as on the back and sides, except where some pale grooves on the skin give it a greyish tinge. It has a dumpty tapering body, being very high in comparison to its length (fig. 27). It measures 16 inches (40·5 cm.) in length, 8¼ inches (21 cm.) in breadth, and 4⅞ inches (12 cm.) in greatest height. When viewed from above it is pear-shaped (fig. 22).

* "Report on the Pelagic Fishes collected by H.M.S. *Challenger.*" *Zoology, Challenger Expedition.* Part LXXVIII. 1889.

† *Nordisches Plankton*, Eier u. Larven von Fischen, I., p. 190. Kiel, 1905.

‡ *Meddelelser fra Kommissionen for Havundersögelser.* Fiskeri, Bind. III. "On the Larval and Post-larval Stages of Zeugopterus, Arnoglossus, Solea." Copenhagen, 1909.

On top of the head there is a single large lure, remarkable both from its size and also from its complexity. The stout stem is hinged at its base, in a depression in the frontal region, between the eyes. It terminates distally in a bladder-like expansion from which wave two pairs of filaments, viz., a very short pair and a long pair. A third pair of filaments is attached to the base of the bladder portion, and below that point come off two more pairs of filaments. All the filaments taper, and the middle pair (or one at least of them) consisted of two branches. The stem and its five pairs of filaments are covered with little membranous scutes which have rounded apices. The following are the lengths of the filaments :—Second pair, 15 and 17·5 cm.; third pair, one side, two branches, common portion, 6·2 cm.; long branch, 16 cm.; short branch, 5·8 cm.; fourth pair, one side, 14·2 cm.; fifth pair, one side, 4 cm.

The second marked feature about the fish is the presence of large membranous scutes on the skin. The scutes vary in size, but they are all of one general form (fig. 28). They resemble very closely the shell of the limpet (*Patella vulgata*), and may be not inaptly termed Patella-scutes. As will be seen from the drawings, they are well scattered over the body, some being found on the pectoral fin. They are present in great number on the ventral surface. The scutes have whitish apices, which are stiff, and in many cases fairly sharp. Some scutes were noticed which had twin apices. The scutes are arranged over the body in a rough but not perfect symmetry.

The eyes are small; they are lateral in position and stand protruding on little stalks (fig. 22). In *Lophius* the eyes are sunk flush in an orbit, as in the majority of fishes.

The mouth is superior. The lower jaw is very deep. There is only one distinct row of mixed teeth in the upper and lower jaws, the larger teeth being on the inner, and the smaller on the outer side. The upper pharyngeal teeth are large, and the rosettes of teeth on the four gill-arches are prominent. There are no lower pharyngeals, and no palatine nor vomerine teeth.

There is a single dorsal fin; it has five fin-rays, and it is placed far back. There are no intervening rays between the lure and the dorsal fin. The last ray of this fin is united by web to the beginning of the caudal fin. The number of rays in the caudal fin is nine. A small anal fin, of apparently five rays, is present. It occupies a position opposite the dorsal fin. There are no pelvic fins. The pectoral fins are small, and they are quite different from those fins in *Lophius piscatorius.* In the latter the pectoral fin is thick and fleshy; it is broader distally than at its origin. It has, moreover, the tips of the first seven rays turned over on to the underside of the fin. The number of fin-rays is 26. In the present fish the number of rays was 16 on the left and 16 (? 17) on the right side. The rays were all soft and membranous. In *Lophius* the pectoral fin practically acts as an operculum. In *Himantolophus Reinhardtii* the pectoral fin is superior to the gill-opening.

The fish might be suitably compared to a small black stone on which a number of *Patella* (sp.) are fastened, and from the summit of which waves a stem of *Fucus.*

Lütken,* who first described this Angler, gave it the name *Himantolophus Reinhardtii.* Gill proposed to remove it to a new genus, *Corynolophus.* There does not appear to be any necessity for such a change. The fish might, I think, have been put originally into the genus *Lophius.* It is a typical Angler, and the points in which it differs from *Lophius* would constitute a good specific description.

The specimens described by Lütken† differed in the number of filaments attached to the lure (viz., from 6–9), and also in the extent to which the

* K. D. Vidensk, Selskab. Skriften, Nat. og. Math. XI., 5. 1878.

† Lütken, Chr.—"Til Kundskab om to artiske Slægter af Dybhavs-Tudsefiske, Himantolophus og Ceratias (*Himantolophus rheinhardti*). [Avec un resumé en Français.] 2 plates. *Vidensk. Selsk. Skr.* 5 Raekke. Naturvidensk. og Math. Afd. xi. 5. Copenhagen, 1878, and *Ib.* Afd. iv. 5, Copenhagen, 1887.

filaments were branched. He said with reference to one of his examples—"The lure ends in a flattened disc, the skin of which is prolonged into two horns and eight elongated tentacles." A drawing of the lure is given, and the filaments are branched in the following manner:—Left side, (1) 4 branches, (2) 4 branches, (3) 2 branches, (4) single; right side, (1) 2 branches, (2) 4 branches, (3) 2 branches, (4) single. In another specimen the lure had, in addition to the two terminal horns, nine filaments, branched as follows:—on one side, (1) 2 branches, (2) 3 branches, (3) 2 branches, (4) 2 branches, (5) single,—on the other side, (1) 4 branches, (2) 4 branches, (3) 2 branches, (4) single. Each branch had a swollen clear tip. Still another of these anglers had a lure bearing six filaments, with a single long terminal tentacle on the disc. Lütken did not think that one should search for specific characters in the lure, which is evidently variable. He said that the tips of the filaments were silvery and possibly phosphorescent. Lütken discusses the question as to whether *Himantolophus rheinhardti* is distinct from *Himantolophus greenlandicus*, Rheinhardt.* The latter was described from a damaged specimen. Its lure, which is shown by Lütken, is very similar, but it had eleven filaments in addition to the two terminal horns.

There would probably have been no doubt as to the identity of Rheinhardt's and Lütken's species if the number of fin-rays given by the former had not diverged comparatively widely from those determined by the latter. I give here a table comparing these data in respect to the Danish and Aberdeen specimens:—

Comparison between *Himantolophus greenlandicus*, Reinh., *Himantolophus rheinhardti*, Lütken, and the Aberdeen specimen in respect to the number of fin-rays.

		Greenlandicus.	*Rheinhardti.*	(Aberdeen.)
Dorsal fin,	..	9	5	5
Pectoral ,,	..	12	17	16 (17)
Anal ,,	..	—	4	5
Caudal ,,	..	—	9	9

There is no doubt that the Aberdeen specimen belongs to Lütken's species.

The Occurrence of the Pilchard (*Clupea pilchardus*) off Aberdeen.

A pilchard, 9 inches (22·5 cm.) long, was caught in a herring net 27 miles E.S.E. of Aberdeen on September 1, 1905.

A *Lophius piscatorius* with One Eye.

This angler was presented by Mr. Eunson. It is shown reduced in fig. 1. The fish was, except for the absence of the left eye, externally normal, but the head was slightly asymmetrical, as is indicated by the shape of the mouth. In the drawing only one sensory-olfactory process (sp) is shown on the upper lip. The other was probably absent although no written note was made of this point. When the skin was dissected off the top of the head in the region of the orbits (fig. 3), two main muscles were exposed, viz., a transverse muscle, *m*., and a longitudinal muscle, *M*. On the blind side a portion of the longitudinal muscle, M^{11}, is inserted in the fascia of the orbit, while the remainder of the muscle, M^{1}, has some strands inserted in the same region. The two tubercles of the frontal which form the upper border of the orbit are exposed on the normal

* Memoires de l'Academie de Copenhague (1837).

side, but are covered with skin on the blind side. The latter are, moreover, smaller than the former.

When the brain was exposed (fig. 4) it was seen that the optic nerve which supplies the left side was absent. In the blind orbit there was a mass of muscles bound together which were apparently the eye muscles, *Em.*, that should have served the left eye. The pituitary body (*pi.*) is remarkable for its projecting a considerable distance in front of the brain. It is attached to the brain by a narrow tube, and is bound *in situ* to the fascia that lines the floor of the cranial cavity. The olfactory nerves arose from a small swelling on the anterior edge of the cerebral hemispheres. I did not make out this swelling in the brain of a normal *Lophius.* The sensory process on the upper lip receives its principal nerve supply from the olfactory nerve.

The under surface of the brain of the abnormal specimen is shown in fig. 5. A small nerve twig (N′) was found alongside the origin of the single optic nerve. It may have been a strand of the optic nerve.

For the purpose of comparison, dorsal and ventral views of the brain of a normal *Lophius* are shown in figs. 12 and 11.

Three Cases of Hermaphroditism in the Cod (*Gadus callarias*).

An hermaphrodite cod was courteously sent to the Laboratory by Mr. Downie, Fishcurer, Whitehills, on February 26, 1910.

The fish was 34½ inches (86 cm.) long. The roe was a large normal pair of ovaries with one small milt attached to the anterior extremity of the right ovary, and a similar small milt attached to the posterior surface at the line of junction of the ovaries. It was of an orange colour, and is shown in dorsal view in fig 59.

The specimen was for a short time in alcohol before it was examined.

The ovary contained yolked eggs; the largest egg observed measured ·8×·9 mm. In the gathering part of the ovary (*non-ov.*, fig. 68), old empty egg-capsules and some small clear eggs were found. The latter did not exceed 1 mm. in diameter. The empty capsules were probably derived from eggs left in the ovary from the previous spawning.

The testis contained white milt, in which the sperms were free.

The testis at the anterior end is supplied with blood from the same vessel that serves the ovary. The stalk connecting the two organs was cut across close to the milt. The section (fig. 64) shows a large vein, *v.*, and several *vasa deferentia.* An artery (*ar.?*) was probably present, but was not made out. Another section made one-eighth of an inch nearer the ovary showed the two *vasa deferentia*, *VD.* and *VD″.*, had united, but the two on the opposite side still remained independent. Where the stalk joins the ovary the wall of the latter exhibits in its thickness a number of slit-like lacunæ. They extend over an area measuring about one inch in diameter; it is indicated in fig. 59 by the dotted line *ch.* A section of the wall here is shown in fig. 60. Solidified white matter was found in one of these spaces. These lacunæ, which apparently serve as vesiculæ seminales, open eventually into the ovary. This is shown semi-diagramatically in fig. 70. A pad of white solid matter resembling milt was found at the opening marked *o.*

A general view of the arrangement of the parts at the posterior end of the ovary is given in fig. 68.

A section through the stalk connecting the testis to the roe is shown in fig. 67. One *vas deferens* had a thick wall and was filled with white matter; the other had a thin collapsed wall, but it also contained a small quantity of white material.

The two *vasa deferentia*, after they arrive at the line of union of the two ovaries, were still to be traced for a little way down on either side of the blood-vessels there. On the internal surface of the ovary

there was much fibrous stroma-like tissue along the suture. Its presence makes the tracing of any openings of the *vasa deferentia* into the ovary difficult. The two wide *vasa* were soon lost. A section through the skin further down showed the blood-vessels and some slit-like vessels or lacunæ on either side. The actual entrance of the *vasa deferentia* into the ovary was not made out.

Another section (fig. 55) was made across the union of the ovaries. One large *vas deferens* enclosing some white matter was prominent. On the opposite side there was a number of lacunæ.

I am of the opinion that all these long chambers open eventually into the ovarian cavity. One or two that were followed by means of a bristle did so.

A second hermaphrodite reproductive organ was presented by Mr. R. Thompson. The cod was caught in the trawl off the West Coast of Scotland on April 3, 1910.

The roe is shown in fig. 54. One ovary, the left, was full-sized, measuring 11½ inches, while the right one was only 5½ inches long. Attached to the latter was a fairly large milt.

Both ovary and testis were ripe. Quite half of the eggs in the small ovary were clear.

Fig. 71 shows a section through the stalk connecting the testis and ovary. *Vasa deferentia* are seen in the middle region, flanked on either side by a pair of blood-vessels. The honeycombed *vas deferens* evidently opened into the ovary.

Mr. Thompson was able to record another hermaphrodite cod which had been captured at Lossiemouth on March 1, 1910.

There is little doubt that in the two cases described above, both the ovary and testis were functional. While in the first case the testis was apparently in advance of the ovary, in the second the two organs were ripe simultaneously. In the latter case there does not seem to be anything to prevent self-fertilisation.

In the Report of the Fishery Board for 1905, I recorded* several cases of hermaphroditism in the cod, and I referred to some previous records of this condition in Gadoids. I omitted, however, the case in the haddock (*Gadus æglefinus*) described by Ramsay Smith.† In it the ovary and the testis appeared to be developing *pari passu*.

Johnstone‡ has published an account of the hermaphrodite condition in the Hake (*Merluccius vulgaris*).

A Peculiar Cod (Gadus callarias) from Loch Fyne.

A cod measuring 82 cm. in length was kindly sent by Mr. Dan M'Lachlan, who attended the course of instruction for fishermen in 1909.

The fish attracted attention from its apparently abnormal shape. Its head was said to resemble that of a ling (*Molua molva*). It is shown reduced in fig. 19.

The external colouration was normal. The ovary was large, and it was not pigmented. The number of vertebræ was 52, quite an usual number. I found nothing abnormal in the head or skull. The teeth were said to be larger than might be expected in a cod of this size. I found, however, that they resembled much the teeth in some skeletons of this fish. In the latter the teeth were not quite so stout, although equally long. But that fact might be accounted for by the drying of the skull.

* "On Two Cases of Hermaphroditism in the Cod (*Gadus callarias*). *Twenty-fourth Annual Report of the Fishery Board for Scotland* for 1905, Part III., 1906, p. 290.

† "A Case of Hermaphroditism in the Haddock." *Ninth Annual Report of the Fishery Board for Scotland*, Pt. III., p. 352.

‡ "An Hermaphrodite Hake." No. XV. *Report for 1906 on the Lancashire Sea-Fisheries Laboratory and Sea-Fish Hatchery.* Liverpool, 1907, p. 209.

The post-clavicle is a bone which varies much, and at first sight its representative in the Lochfyne specimen gave room for doubt, but it, I found, agreed also with its counterpart in other cod.

Although the fish was a little misshapen, I do not think it was other than a normal *Gadus callarias.*

Stone in the Bladder of a Cod.

Mr. M'Lachlan also forwarded an urinary bladder of a cod which contained a large stone.

The roe, with the urinary bladder attached, is shown reduced in fig. 13. The roe, which was ripening, measured 4½ inches in greatest length. The urinary bladder consists of two lobes, one which is practically of normal size (*lo.*), and the other very much enlarged (*lo*[1]). The latter contained a large stone, which is shown in natural size in fig. 17. The ureter (*ur.*) had been cut away. The drawing of a normal urinary bladder (*ur. bl.*) is provided in fig. 18. It is made to the same scale as fig. 13. Dr. Milne, University College, Dundee, informs me that in its chemical composition the stone resembles the urinary calculus of the human subject.

Several smaller calculi were found in the interior of a cod at Aberdeen. They had evidently been in the urinary bladder. The largest was about ½-inch in diameter. They were not perfectly spherical.

Cod Bitten by a Cephalopod Mollusc? (Figs. 29 and 34.)

Two prominent scars (*scr.*) were found on the shoulder of a large cod. In the fresh condition the scars had a greenish colour. They appear to have been due to the bites of cuttlefish (Loligo or Octopus), as described by M'Intosh.* The part had been preserved in formaline before examination.

The sores have filled up with tissue consisting of fascia and muscle. The ends of two ribs (*r.*, fig. 94, shown in dotted lines) are tightly bound to the posterior scar, while the anterior scar has below it the head of the post-clavicle (*pt. cl.*, *ib.*), which has been exposed apparently by the excision of a portion of the clavicle. The head of the post-clavicle is normally covered by the clavicle.

A section through the larger scar is shown in fig. 29. This scar has a distinct rim or margin (*rm.*, figs. 29 and 34). The epidermis is absent from the uninjured skin, having evidently been rubbed off. The section shows to the right the normal derma (*d.*), containing the scale-pits (*scp.*), and having its outer layer pigmented (*p.*). The pigmented layer ends at the edge of the scar. On the surface of the scar there is a soft layer of dead tissue (*d.t.*), greenish in colour. Beneath it is seen the live tissue, which is also stained a pale green. The scar has been healed by the lateral outgrowth of the tough white derma. It forms the broad rim (*rm.*). The part of the scar within the rim, and next to it, is formed by the great development of the lighter layer of fascia (*f.*) below the derma, which has accompanied the latter in its outgrowth. The central part of the wound (*c.*) is occupied by a pad consisting in its outer rind of fascia and fibres tightly bound together. It forms a protective layer which is not sharply separated off from the muscles beneath. In parts the cortex can be split longitudinally in the same sense as the run of the muscle-bundles; in other parts the rind will not split readily.

An encysted parasite was embedded in the scar. It resembled much the trematode cysts found in the skin of the whiting (*Gadus merlangus*). *Vide*

* (1) "Injuries to Baited Hooks and to Fishes on the Lines." *Fourth Annual Report of the Fishery Board for Scotland* for 1885, p. 203. 1886.

(2) "Further Remarks on Injuries to Food-Fishes on the Lines." *Tenth Annual Report of the Fishery Board for Scotland* for 1891, Pt. III., p. 299. 1892.

below. There was no black pigment associated with the cyst, and the larva within it was not so far advanced as those found in the whiting. I was able to make out no definite characters. The cyst measured ·75 × ·62 mm.; it had a very thick rind.

Injured Gadus callarias.

The small cod referred to on page 61 had lost the whole of its tail (fig. 41). The wound had, however, healed up, and the fish was well nourished.

On May 5th, 1902, a cod was got in the trawl in the Moray Firth which had some of the opercular and branchiostegal bones exposed. The branchiostegal membrane had been torn, and one ray projected, with the greater part of its length bare of flesh. It had a thick crop of Zoophytes and stalked infusors growing on it (fig. 42; *s.* indicates the outside of the skin of the fish). The bone was $2\frac{1}{4}$ inches long, and $1\frac{5}{8}$ inch was exposed. The surface of the bone was decaying, and could be scraped off as a white powder. Several small nudibranchs were found among the Zoophytes.

Tumours from the Cod (Gadus callarias). (Figs. 45, 52.)

The larger tumour was sent to the Laboratory on 26th February, 1907. It, along with a number of other abnormal specimens, have been generously supplied by Mr. Angus. It had apparently been attached to the gullet. A mark had been observed on the wall of the abdomen, against which it pressed. It weighed 2 lbs., and measured $6\frac{1}{2}$ inches by $5\frac{3}{4}$ inches by $3\frac{1}{2}$ inches (fig. 45). It was fibrous, composed of laminæ, concentric in parts, with radiating fibres. It was supplied with large blood vessels. An opening led into a narrow slit-like cavity, which is shown exposed in fig. 52. The surface of this cavity was in part white and clean; the remaining portions were discoloured, and had a dried substance adhering. One large vessel was discharging a thick whitish fluid into the cavity.

Prince* described a tumour from a cod. It was evidently a connective tissue capsule formed around a foreign body in the peri-visceral cavity; this foreign mass, like a large fragment of undigested food, lying outside the walls of the alimentary canal.

A tumour obtained on 18th February was attached to the wall of the stomach, within an inch of the pylorus. It is egg-shaped (fig. 57); it measured 4·5 cm. in length, 2·8 cm. in breadth, and it rose to a height of 2·5 cm. above the outside surface of the stomach wall. It is solid, and quite smooth externally, with fine blood-vessels showing as little red streaks.

The wall of the stomach is composed of two external layers of muscles and a thick white fibroid layer which forms the internal surface. The muscle-layers run at right angles to each other; they are bound tightly together. The thick white fibroid layer is almost as thick as the muscle-layers, and is separated from them by connective tissue. The muscles are inserted into the fibroid layer. The latter shows its surface marked all over with closely-set dimples.

The tumour seems to be composed almost entirely of muscle and fibrous tissue binding the muscle together. It has apparently been formed by the great local growth of the inner layer of muscles. The outer layer of muscles forms an outer coat to the tumour. External to the muscle there is a thin fibrous skin. The tumour is separated from the cavity of the stomach by the fibroid layer alone. Fig. 63 shows the inner surface of the stomach at the part. The position of the tumour is indicated by a dotted line. That part of the stomach wall is smooth, but there are ridges round it. A

* "On an Internal Tumour from the Abdomen of a Cod." *Tenth Annual Report of the Fishery Board for Scotland* for 1891, Pt. III., p. 324. 1892.

nematode is shown (*ne.*) in a hole in the stomach wall, from which it could not be withdrawn.

Tumour on the Tail of a Cod (24th November, 1909).

The tumour was a red-coloured mass projecting as a round swelling from the side of the fish just above the second anal fin (*tu.*, fig. 61). It was covered up with a soft white layer which has been formed by the coagulation of the secretion poured out of the sore.

The coagulated secretion extends on to the skin on both the anterior and posterior sides of the tumour. Underneath the secretion the derma is bleached. Anterior to the point *p.* (fig. 58) the pigmentation is normal.

When the sore was pressed a thickish and pale white fluid was poured out. The tumour was then like a sponge, from which the matter oozed at various openings. The secretion coagulated in water.

Under the microscope this fluid is seen to be composed of a granular fluid in which are yellowish rod-like or spindle-shaped bodies, apparently crushed and disorganised blood corpuscles, and pale round corpuscles containing bright granules.

A longitudinal section of the tumour is shown in fig. 58. The derma is thickened beneath the sore; the channels crossing this layer obliquely are very wide, they apparently give passage to blood-vessels. The connective tissue layer between the derma and the muscles is also much thickened and supplied with large blood-vessels. The cuticle is absent. The scale-pits (*scp.*) are enormously increased in size. They are filled up with a much-folded and branched ribbon-like frill (*fr.*). This frill is red, and it is well supplied with blood-vessels. The loops formed by the latter are well seen at the top edge. The frill is dotted all over right down to the bottom of the scale-pit with little black pigment spots. Its surface is covered, in parts at least, with little short tubules (fig. 62) which are arranged so closely that the tissue resembles a skin covered with hairs. In end view they appear round, with a circle which might be either a pore or a nucleus visible within them. In side view an oval body is seen within, near the tip. The little tubules break off and are found free in the secretion that is pressed out.

The frill is scalloped and is sub-divided into numerous irregularly-shaped pieces. It secretes the fluid, which lies between the folds, and collects in the middle of the scale-pit. In fig. 65 a surface view of a part of the tumour exhibits the frill (*fr.*) and the secretion (*se.*). Where the secretion is forced out of the tumour, the pits are completely filled up by the frill.

In the centre of the sore the inflammation and extra growth are inside the scale-pits. The latter are very large. In one, at least, a small scale was found. The scale in some pits is partially eaten away.

On the posterior side (*post.* fig. 58), beneath the secretion, the papillæ of the derma (*pa.*) are lengthening and becoming suffused with blood. They would eventually develop into frills I believe. The scale-pits posteriorly show a reddish hue.

In the derma the gland openings occur as very little clear spaces in the pigmented outer layer. Near the tumour these glands are enlarged and the region is slightly reddish.

The skin of the trunk along the base of the anal fin seemed to be drawn to some extent, but was not affected.

The tumour may have arisen in consequence of something having adhered tightly to the skin, to which it remained attached long enough to cause local inflammation. The secretion from the tumour can evidently cause this, as is shown by the condition of the skin at the edge of the tumour. The inflammation has resulted in the development of the frills from the derma both inside and outside the scale-pits.

On the ventral edge of the body, between the second anal and the caudal fins, there was a small sore (*so.* fig. 61). This may have been caused by some of the secretion having become attached at that point under shelter of the fins.

A whiting had a partially healed sore. The scar was 3 cm. in diameter, and seemed to have resulted from a tumour similar to that just described.

Tumours on the Lemon Sole (*Pleuronectes microcephalus*).

Tumours resembling that just described were found on a Lemon Sole in the spring of 1909 (fig. 66). Three of the sores represented a secondary condition in which the diseased skin had been removed either partially or wholly, as in the case of the most posterior tumour where the muscles are exposed.

The fish had been in formaline for some time before it was examined.

One tumour had a long process lying on the top of the skin (*tu.*). A longitudinal section was made through the tumour (fig. 69). It showed what appeared to be a group of cysts between which the derma was interdigitated. The cysts are, however, no doubt simply the solidified secretion. The solid is finely granular. The external process was granular in structure and was probably coagulated secrètion. A scale from the outside of a part of the tumour was partly eaten away. It is shown semi-diagrammatically in fig. 56.

Disease in the Skin of Onos mustela.

In this connection it may be noted that a disease appeared in the skin of a five-bearded rockling a few days after the fish had been handled.

The fish, which was living in one of the tanks of the Laboratory, had become ripe. It was, however, unable to get rid of its eggs, and the abdomen became very much distended. I caused a considerable quantity of the ova to flow out by passing my fingers from before backwards along the side of the abdomen a number of times. The fish was replaced in the tank, and in a few days the skin over the region that had been rubbed was very much inflamed. When examined it was found that the epidermis was absent from the region.

Tumours in a Zoarces viviparus.

A viviparous Blenny (*Zoarces viviparus*) was obtained from the estuary of the Dee. Its body was much distended, and it was kept alive as it was thought to be carrying young (fig. 43). It died at the end of several months' stay in the tank, and when opened the swelling of the abdomen was found to be due to tumours which were located in the abdominal wall (*T. T.'* figs. 36 and 43). They projected into the abdomen and reduced the cavity very much. The two hind tumours (*T.'* fig. 36) met in the hind part of the abdomen. The abdominal organs were crushed to one side in the anterior region. A number of tumours were present in the tail portion of the body. The fish was sent to Dr. F. M. Milne, Pathological Department, University College, Dundee. From a preliminary examination he concluded that the tumours do not suggest a true new formation of tissue, but rather something parasitic (*sporidial*).

Spotted Whiting (*Gadus merlangus*), *Cod* (*Gadus callarias*), *and Lythe* (*Gadus pollachius*). (Figs. 24, 30, 32, 33.)

Four spotted whitings were obtained at Aberdeen in October and November 1909. They measured from 12½ inches (31 cm.) to 16 inches (40 cm.) in length. One of them is shown reduced in fig. 24.

In general appearance the fishes were well nourished and normal,except that they were thickly covered all over the body and fins with black dots. Under the lens, each black dot was seen to be a little oval translucent cyst surrounded by an irregular ring of black pigment. They are shown enlarged in fig. 30, where they appear shining through the scales.

In a section of the skin it is seen that the cyst occupies the whole thickness (fig. 33). It rests inferiorly on the layer of fascia (*l. l.*) between the skin and the muscles. It reaches above into the lower surface of the scale-pit (*scp.*). The epidermis is not shown in the drawing. Some of the cysts reach the surface in the inner part of the scale-pit, in which case they are, although surrounded by pigment, not visible from the outside.

The cyst measured ·35 × ·3 mm. and the oval body within was ·22 × ·2 mm. in size. When the cyst was dissected out of the skin it was found to be very tightly bound to the fibres (fig. 32), and these fibres formed a zone round the body; they did not cover its whole surface.

The trematode character of the larva was evident. The skin was longitudinally and transversely grooved. I was not able to make out any spinules on the skin. The cyst had two investments, the outer a thick rind, the inner a thin membrane closely applied to the larva.

The cysts were found also in the cornea, on the eyeball within the orbit, on the inside surface of the mouth, and some were sunk in the muscles of the dorsum, and head. They were revealed by the black pigment accompanying them. In the eye, some cysts which were lodged in the gelatinous matter between the cornea and the lens had no pigment.

A large number of cysts were found within the brain cavity, in the spinal canal, and in several spinal nerves. The nerves were distended at the points where the cysts were located. There was no black pigment associated with these. None were observed in the tissue of the brain or of the spinal column. Two cysts from the auditory organ measured 1 × ·5 mm. and ·55 × ·4 mm. Four empty capsules were observed in the same organ. A cyst was found between the muscles and the top of the skull. It measured ·7 × ·57 mm.

The cysts found in the nerves, measuring ·6 × ·4 mm. and ·55 × ·35 mm. in size, contained larvæ that resembled exactly those of *Gasterostomum gracilescens* as figured by Lebour* (*Plate I., figs. 2 and 3*). They were larger than those in the skin, and contained young forms of a more advanced stage. The cyst had a double-layered investment. The larva exhibited a different appearance in its integument according as it was extended or contracted. In the latter case the rugæ were very prominent. Anteriorly the surface of the skin exhibited a net-work appearance. At the edge, the body appeared serrate and the backward directed teeth described by Johnstone† were made out. Posteriorly, while the faint transverse grooving was evident, no spinules were made out. In surface view the net markings on the anterior end were accompanied by comb-like structures which may have been groups of teeth. When the trematode is extended it is very difficult to make out the above-mentioned structures. The teeth were not definitely seen in that condition of the worm.

The pigment which surrounds the cyst does not apparently belong to it, because in certain regions the pigment was absent. The presence of the parasite would seem to stimulate the development of pigment in the surrounding tissue.

Four spotted whitings, measuring in one case 31 cm., were examined in February. The embryo parasites did not seem to be any further on than those described above. Four others were obtained in March. Of these, one

* Lebour: "Fish Trematodes of the Northumberland Coast." *Northumberland Sea-Fisheries Report* for 1907.

† "Johnstone: Internal Parasites and Diseased Conditions in Fishes." *Trans. Biol. Socy., Liverpool*, Vol. xix., 1905, p. 98.

was a ripe male. The fish were in sufficiently good condition. One cyst taken from a nerve had an embryo that appeared a little further advanced than those previously examined.

Parasites similar to the above were found in the skin of a small cod which had no tail. (*Vide* p. 57.) The fish in its mutilated condition measured $10\frac{7}{8}$ inches (27·5 cm.) in length. The cysts were of approximately similar size to those of the whiting, and had black pigment surrounding them. One cyst measured ·35 × ·27 mm.; it had a thick rind.

Two small cod and two little lythe were infected with the same Trematode. The cod measured 7·5 and 8 cm. in length, while the lythe were 10 and 10·5 cm. long. One of the lythe was examined. The spots resembled exactly those on the whiting. They were scattered over the sides, fins, and eyeball. None was made out in the spinal nerves. One cyst measured ·35 × ·25 mm.

The parasite is evidently *Gasterostomum gracilescens.*

Johnstone observed this species in the brain of *Gadus æglefinus* and *Phycis blennoides.* He also found a *Gasterostomum* (*sp.*) encysted in the muscles of *Pleuronectes platessa.* The cysts were, in the case of the larger, faintly brown, or dull-red in colour. Lebour found the former species common in the nerves of the *Gadus æglefinus*, *Gadus callarias*, *Gadus merlangus*, on the Northumberland coast. She does not mention its occurrence in the skin.

Nicoll* observed a very similar parasite (*Distomum, sp.*) in *Cottus bubalis.* He found the muscles, skin, bones, and layers of the eye impregnated with small masses of black pigment, accompanied by cysts containing Trematode cercariæ. The only parts of the fish not affected were the brain and abdominal organs. The pigment-spots appeared to follow the course of the blood-vessels, and they are probably spread throughout the body by means of the blood.

Nematodes in the Muscle of the Cod (Gadus callarias).

A codling was observed to have a large number of nematodes scattered through the muscles. The worm lay coiled up in a cavity which it has formed by pressing apart the muscles (fig. 26). The muscles do not appear to be injured at the part. The nematode is reddish-coloured at either extremity. It is enclosed in a light skin of connective tissue, and the cyst itself is lined with fascia which is bound to the muscles. The worm has thus two investments. The cyst is sometimes red-coloured owing to its being well supplied with blood vessels. The coils of the nematode pass through the fascia which often shows well developed blood plexuses, (*bpx.*, *bpx.'*, fig. 20). In one case a pillar of tissue joined the floor of the cyst to the roof (fig. 31). The nematode was coiled round the pillar which was red with blood vessels.

A cod fillet containing similar worms had been prepared in the usual method. It had been in pickle for half-an-hour, and then had been in the smoke-kiln for the customary period, viz., from three-quarters of an hour to two hours. It was received on 17th December, and was kept until the 30th of the same month, by which time it was smelling offensively. Live worms were dissected out at intervals from the 17th to the 30th. The fish was, so far as it could be judged by smell, good on the 25th.

A piece of cod infected with these parasites was dried in the open air without any preservative. Three months later the fish was examined. It was quite hard. The worms when removed from the muscle were translucent, amber in colour. They were dry, flattened, and tough. When one was put

* Nicoll: "A Contribution towards a Knowledge of the Entozoa of British Marine Fishes." *Ann. and Mag. Nat. Hist.*, xix. (7), 1907, p. 66. See also *ib.* xvii. (7), 1906, p. 148; xx. (7), 1907, p. 244: iii. (8), p. 237: iv. (8), p. 1.

into water, either sea water or fresh water, it swelled up and became plump. It then gradually turned white. Shortly after the worm was put into the water a little movement was detected in one or two cases, but there was no clear evidence that the nematodes were alive. After they had been some time in the water no further movement was detected. Even when alive these worms are often very sluggish.

Sand-eels (Ammodytes sp.) and an Hermit-Crab (Eupagurus bernhardus) encysted in the abdominal cavity of the Haddock (Gadus æglefinus), Cod (Gadus callarias), and Saithe (Gadus virens). Figs. 35, 38, 39, 40, 44.

A number of examples of this condition have been obtained among fish landed in Aberdeen. They have been kindly supplied by Mr. B. Erlandsson.

The sand-eels, after being swallowed by the fish, have escaped from the gut and passed into the abdominal cavity. There they have generally damaged the liver before they died. Sometimes they are found with the head or tail jammed tightly into the space between the reproductive organ and the peritoneum. They are covered with a material which resembles a hardened paste, and in some cases they are in part enclosed in a skin of connective tissue derived from the peritoneum. In this way they are reduced to a mummified condition.

The fishes, which had acted as hosts, had all been gutted ; an opportunity did not therefore occur of seeing the condition of the gut.

One large sand-eel was most commonly found in the cavity, but in one case three small sand-eels were present.

Fig. 38 (Haddock, 6 Feb. 1909), represents a condition where the sand-eel (*s.*) 6½ inches (16·5 cm.) long had pushed its head through the liver (*l.*) Posteriorly the fish was attached to the peritoneum and to a portion of damaged tissue (*g.*)

Fig. 39 (Haddock, 19 May 1909). In this case the head of the sand-eel was directed posteriorly. The tail had been pushed into the liver which had become attached (*at.*) to the peritoneum. Beneath the middle portion of the fish, that is, between it and the peritoneum, there is only a shred of liver tissue. The sand-eel was covered with a paint-like coat.

Fig. 40 (Haddock, 4 October 1909). Three small sand-eels, measuring 2½ or 2¾ inches (6–7 cm.) long, (*s.′*, *s.″*, *s.‴*) were free in the abdomen. The ovary is much shrunk and wrinkled as if it had been a spent. Two of the sand-eels had their heads tucked in between the ovary and the wall of the abdomen. The ureter (*ur.*) was severed from the urinary bladder (*ur. bl.*), but that may have been done when the fish was gutted. The ovary had become attached to the peritoneum along the edge (*at.*).

Fig. 35 (Cod, 22 May 1909). The cod measured about 24 inches (60 cm.) in length. The sand-eel (*s.*) had poked its head into the loose peritoneum on the outer side of the testis. Small cycloid scales could be made out in the skin of the sand-eel which was completely dried.

Fig. 44 (Cod, 24 Sept. 1909). The sand-eel had in this case destroyed the liver, which is in three detached portions (*l.*, *l.′* *l.″*). The portions (*l.* and *l.″*) seem healthy. The part (*l′*) is very dark, and unhealthy looking. The portion of liver in the anterior part of the cavity was enclosed in a loose skin (*sk.*) which was attached to the peritoneum and swim-bladder. In the normal condition the liver is here quite free from any attachment to these parts. The liver was as it were in a pouch. The sand-eel lay with its head pointed anteriorly, and having its tail poked into the mesentery between the two ovaries (*ov.*). There are additional growths of tissue attached to the peritoneum at (*x.*). The piece of liver is also attached to the peritoneum. Where new tissue is superimposed on the peritoneum the pigment dots in the latter are concealed or are only faintly visible,

A large sand-eel, 7¾ inches in length, was lying along the dorsal region of the abdominal cavity of a codling (March 11). It was thickly plastered with hardened paste. Its tail was twisted round the urinary bladder. The skin of the liver which had evidently been destroyed was attached to the peritoneum as a thickened wall along the ventral part of the abdomen.

Another codling had a very small sand-eel, 2⅝ inches long, coiled up at the anterior end of the abdominal cavity. The anterior third of the fish was buried in the liver, and the liver had grown attached to the peritoneum.

A sand-eel was discovered in one saithe. It was adhering to the abdominal wall.

Fig. 47 is a drawing of an Hermit-Crab adhering to the internal surface of the abdominal wall of a cod. Dr. T. Scott kindly identified the crab as *Eupagurus bernhardus.* It is in perfect condition. The shell is clean, and quite hard. It covered a stretch of 3 inches (7·5 cm.). One of its limbs was in part covered with the white paste (*ps.*) and two were attached to the peritoneum at (*at.*). The remainder of the body was free. The crab had escaped from its Molluscan shell. Its chelæ and one walking limb had made impressions in the wall of the abdomen, that caused by the dactyl of the second pereiopod, being ¼-inch (6 mm.) deep (*x.*). A small strand of white tissue was attached to the dactyl, but not to the peritoneum. Lying between the pagurid and the wall of the abdomen were parts of the limbs of a smaller Crustacean apparently *Galathea* (*sp.*), and also a thin-walled tube quashed and torn.

A nematode was found close to the hermit-crab. It was dead. It was surrounded by small white concretions attached to connective tissue, and all over its surface were similar white bodies (fig. 48). Under the microscope it was seen that the concretions attached to the worm were under the integument. They, in many cases, had the skin raised into a papilla over them (fig. 50), indicating that they had probably been the larvæ which were trying to push their way out of the body of the parent. The larvæ were elongated bodies.

Barrett* described a sand-eel lying on the liver and partly attached to it. It was covered with a white coat which had become attached to the liver. He suggests that the sand-eel may have escaped from the gut to the abdominal cavity of the haddock by passing along a pyloric cæcum. And having once forced a passage to the blind extremity of such a cæcum, either it should force its way through the end, or that the dilated tube should break off at some point, giving to the passenger a tight-fitting cuirass, and at the same time setting it free in the abdominal cavity, there to die, and to become encysted partly by pressure and partly by inflammatory adhesion in some soft organ such as the liver.

While the mode suggested by this author might be the actual method of escape in certain cases, it nevertheless seems probable that if the sand-eel passed while alive from the stomach into the gut, it would be able to rupture the latter at any part. But the perforation of the alimentary canal is not due alone to the effort of the sand-eel, as the last instance described above shows. The hermit-crab, it seems evident, must have passed out by a perforation of the stomach. It does not appear likely that it could have made its way into the gut.

It is therefore not necessarily the case that either the sand-eel or the Eupagurus were the sole agents in causing the lesion which afforded them exit. A weakened condition of the wall of the stomach (due to parasites or disease) may have afforded the sand-eel an opportunity of rupturing it.

* "Note on the Liver of an Haddock in which a Sand-eel was Partly Embedded," *Third Annual Report of the Fishery Board for Scotland* for 1884, p. 70. 1885.

Abnormal Ovary of an Haddock (*Gadus æglefinus*).

A peculiar roe of an haddock was received from Mr. Erlandsson on February 12, 1910 (fig. 51A). It was hard, tough, and of a red colour. It was the left ovary; it measured 2¼ inches in length. The outer surface was finely tuberculated or bossed.

It was evidently an ovary that had been ripe, but which had not been spent. Internally, the ovary was dry towards the rind. About the centre it was suffused with red. The eggs were semi-translucent and hardened. They were apparently still in follicle. The ovarian tissue was suffused with blood. There seemed to have been hæmorrhage inside the ovary.

Abnormal Skate (*Raia circularis and Raia clavata*). (Figs. 37, 49, 49A.)

An abnormality which, while not common, is not very rare, is the partial separation of the pectoral fin from the snout.

Three instances have come under my notice. A well marked case occurred in a male Cuckoo skate (*Raia circularis*) which was landed at Aberdeen in September 1909 (fig. 37). The separation extended backwards to the level of the edge of the orbit. The tips of the pectoral fins bore large hooked spines, similar in size to those that bordered the orbit. This is a character of the male fish; the female shows only small spines on the anterior corner of the fin.

If the lateral peaks be pressed in to touch the snout, a practically normal condition is attained.

It might be suggested that this abnormality may have been caused by a fisherman who had cut into the fore end of the skate and then set it free. The separation is, however, carried exactly along the dividing line between the snout and the fin, on either side. No part of the fin-rays or muscles was left attached to the snout. It would, therefore, appear probable that this condition has occurred naturally.

Two cases were observed in *Raia clavata*, and both of the fishes were female. One of these (fig. 49a.) measuring 18¾ inches across, closely resembles the *circularis*. The other (fig. 49) was somewhat different. This skate measured 18 inches across the body. The anterior ends of the pectoral fins are notched, but in a manner different from the cases just cited. The clefts are smaller and offer a wider angle. Here, moreover, the most anterior fin-rays and their muscles remain attached to the snout on either side. The angle between the fin-rays, that are directed anteriorly and those turned laterally, is filled with muscles in which the bundles run in two directions at least (fig. 50).

In this case also, if the abnormality has been artificially caused, the fish has been very accurately cut to form a symmetrical figure.

There were six pairs of external gill-openings. The sixth pair was not, however, functional. The slit was imperforate, being simply a depression in he skin.

Day exhibits a similar monstrosity in this species, and Johnstone* describes a small *clavata* which had clefts which entered the body nearly as far as the first gill-openings. The last fish was apparently in good health when it was captured. An example recorded by Traquair† was not so deeply cut as the preceding specimens.

* "Ray showing Arrested Development of the Pectoral Fins." No. xiv. *Report* for 1905 *on the Lancashire Sea-Fisheries Laboratory and Sea-Fish Hatchery*, Liverpool, 1906, p. 188.

† "Note on an abnormally developed Thornback (*Raia clavata*, L.)" *Annals of Scottish Natural History* for 1892, p. 29, fig. —.

On the Effectiveness of a Seine-trawl in a Small Pond.

On June 16th, some years ago, when the pond at the Laboratory was about to be cleaned, it was necessary to remove the plaice. This was done by means of a seine-trawl about 57 feet long. The pond measures 90 feet by 35 feet, but the whole of this area was not worked over. Eighteen feet of the shallow portion of the pond was not netted (shown shaded in fig. 53). The deep end harboured most of the fish, which were large plaice.

The seine (*ne.*, fig. 53) was run out and dropped down the front of the wall at the deep end. The ground-rope was allowed to sink and then each end of the net was drawn along one of the long sides. One end was taken across the pond near the shallow end and the two ends of the net hauled together in the corner. When the work was started, there was a depth of about 5½ feet at the deep end and 2½ feet at the shallow end, while at the intermediate portion, where the net was taken ashore on one set of drags, there were 3 feet of water. For the next haul the net was taken in the opposite direction, and hauled at the deep end. It was then worked to the deep and shallow ends alternately. During the experiment, the water was flowing gradually out of the pond, and after a time the men were able to take the net ashore on the dried shallow end. The trawling was continued as long as it was effective, that is, until about half of the bottom of the pond was dry. The water remaining then was very dirty with fine mud. There would be about 18 inches of water left at the deep end.

Seventeen drags were made, and the number of fish captured in each was recorded. The direction in which the haul was made is indicated in the following table by the letters "D" and "S." "D" indicates that the haul was made towards the deep end, "S" that the haul was made towards the shallow end.

Number of Drag.	Direction.	Number of Plaice.	Number of Drag.	Direction.	Number of Plaice.
1	S	24	10	D	7
2	D	16	11	S	24
3	S	15	12	D	4
4	D	4	13	S	9
5	S	22	14	D	4
6	D	13	15	S	10
7	S	35	16	S	4
8	D	4	17	S	2
9	S	25			

There were actually 282 large plaice in the pond. Of these 222 were taken by the net. 60 plaice were left in the pond.

One of the plaice had not yet got rid of its ripe eggs.

LETTERS USED.

a.—Anus.
2 a.—Second anal fin.
ar.—Artery.
at.—Attached edge.
bl.—Bladder.
br.—Brain.
bv.—Blood-vessel.
c.—Central region.

d.—Derma.
di.—Blasto disc.
bpx.—Blood plexus.
cl.—Clavicle.
d. t.—Dead tissue.
ce.—Cerebrum.
e. m.—Eye muscles.
f.—Fascia.

LETTERS USED—*continued.*

fn.—Fin-ray.
fr.—Frill.
g.—Gut.
hæ.—Hæmatosac.
ht.—Heart.
in.—Infundibulum.
l.—Liver.
la.—Larva.
lac.—Lacuna.
lat.—Lateral line.
li.—Lobi inferiores.
l. l.—Lower layer.
lo.—Lobe.
lov.—Left ovary.
M, *m.*—Muscle.
me.—Mesentery.
n.—Nerve.
ne.—Nematode.
non.-ov.—Non-ovigerous part of wall of ovary.
o.—Opening.
oc.—Eye.
og.—Oil globule.
ol.—Olfactory nerve.
op.—Optic.
op. cl.—Opercular cleft.
oper.—Operculum.
oplo.—Optic lobe.
ov.—Egg.
ovd.—Oviduct.
p.—Pigment.
pa.—Papilla.
pect.—Pectoral fin.
pel.—Pelvic fin.
pf.—Pectoral fin.
pi.—Pituitary body.
post.—Posterior side.
ps.—Hard paste-like material covering the encysted sand-eel.
pt. cl.—Post clavicle.
r.—Rib.
rect.—Rectum.
rm.—Rim.
r. ov.—Right ovary.
s.—Sand-eel.
sc.—Scale.
scp.—Scale-pit.
scr.—Scar.
se.—Secretion.
sg.—Segmentation cavity.
sk.—Skull, skin.
so.—Sore.
sr.—Surface.
sw. bl.—Swim-bladder.
T.—Tumour.
test.—Testis.
tu.—Tumour.
ur.—Ureter.
ur. bl.—Urinary bladder.
urg.—Urogenital aperture.
v.—Vertebra.
vd.—Vas deferens.
vn.—Vein.
vt.—Vitelline membrane.
w.—Wall of Stomach.
x.—New growth of tissue (fig. 44).
y.—Yolk.
z.—Zona.

EXPLANATION OF PLATES.

PLATE II.

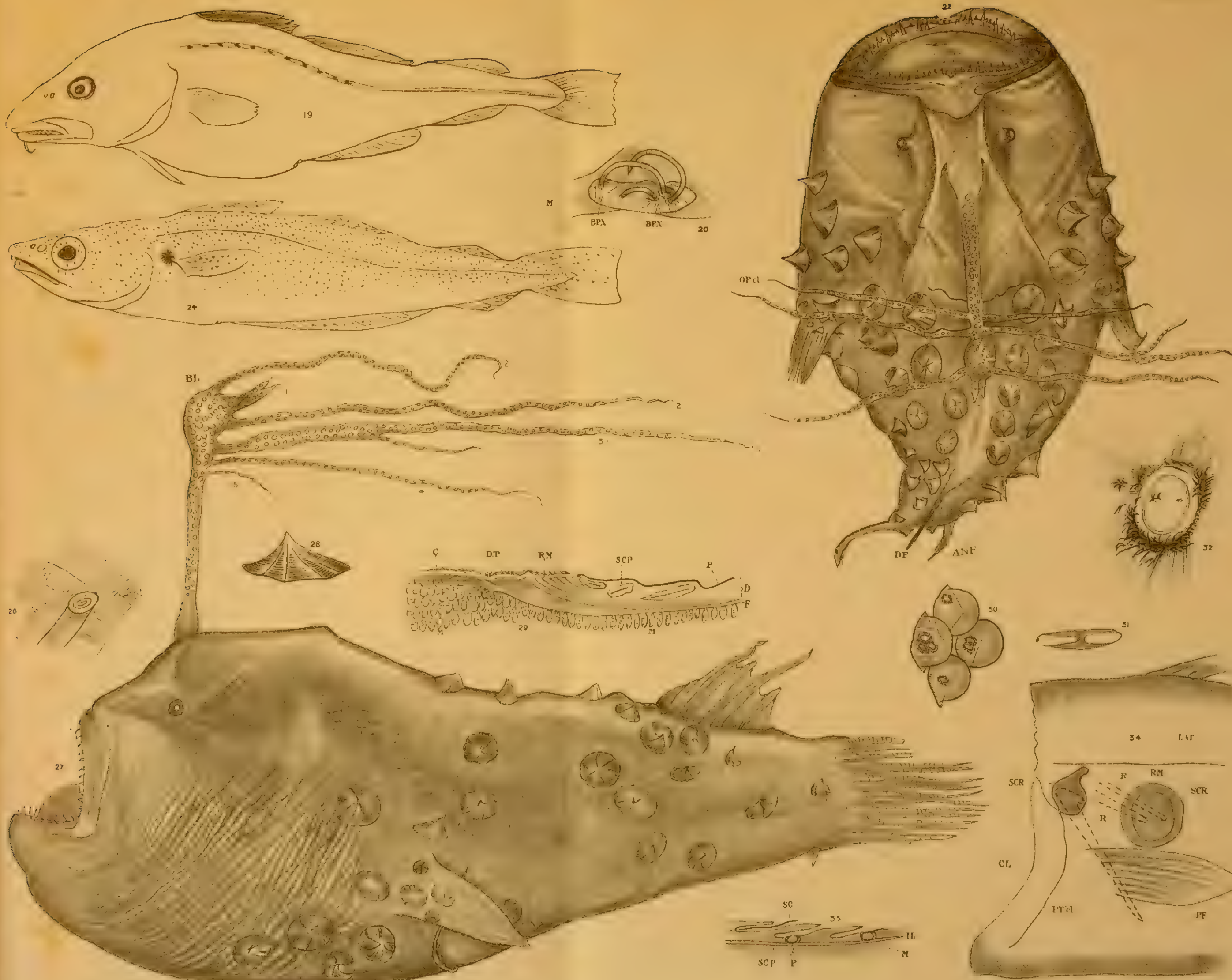
FIG. 1. *Lophius piscatorius*, with one eye. × $\frac{1}{5}$.
,, 2. ,, ,, larva, 5·5 mm. long. 17th July 1907.
,, 3. Head of *Lophius piscatorius*, with one eye. Skin removed.
,, 4. ,, ,, ,, ,, ,, Brain exposed, dorsal surface.
,, 5. ,, ,, ,, ,, ,, ,, ,, ventral ,,
,, 6. *Lophius piscatorius*, post-larva, 9 mm. long. 29th September 1907.
,, 7. Drawing of egg of *Hippoglossus vulgaris*. Enlarged.
,, 8. ,, Zona of egg of ,, ,, ,,
,, 9. *Lophius piscatorius*, larva, 8 mm. long. 24th July 1907.
,, 10. ,, ,, ,, 6 ,, ,, 22nd ,, ,,
,, 11. ,, ,, normal, view of brain from below.
,, 12. ,, ,, ,, ,, ,, above.
,, 13. Abnormal urinary bladder of *Gadus callarias*.
,, 14. Post-larval *Arnoglossus, sp.*, 9 mm. long. 12th September 1899.
,, 15. *Lophius piscatorius*, 5·5 mm., tow-net, Loch Fyne. 28th July 1899.
,, 16. Enlarged drawing of anterior end of *Arnoglossus, sp. Vide* fig. 14.
,, 17. Stone from urinary bladder of *Gadus callarias*. *Nat. size.* *Vide* fig. 13.
,, 18. Normal ,, ,, ,, ,, Reduced.

PLATE III.

FIG. 19. Abnormal (?) Cod from Loch Fyne, Spring 1909. 32 inches (82 cm.) long.
,, 20. Drawing of cyst in dorsal muscle of *Gadus callarias* containing a nematode.
,, 22. *Himantolophus reinhardtii*, from above.
,, 24. Spotted *Gadus merlangus*, 12½ inches (32 cm.) long.
,, 26 Drawing of cyst in muscle of *Gadus callarias*, containing nematode.
,, 27. *Himantolophus reinhardtii*, side view. × $\frac{1}{2}$.
,, 28. Patella-scute of *Himantolophus reinhardtii*. *Nat size.*

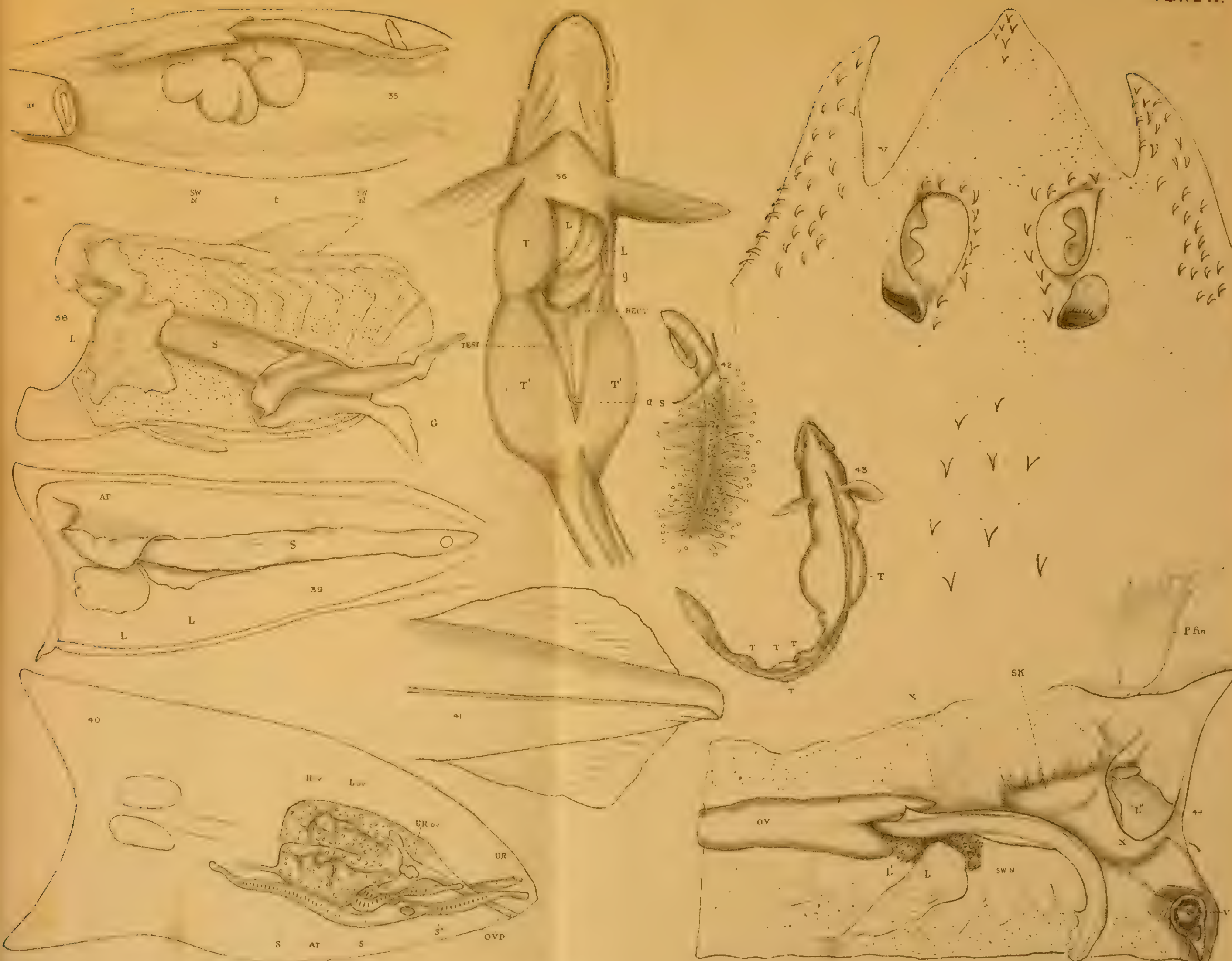
H. C. W.

Lophius piscatorius, Hippoglossus vulgaris, Gadus callarias, Arnoglossus sp.



H. C. W.

Himantolophus veinhardtii: Gadus merlangus, Gadus callarias.



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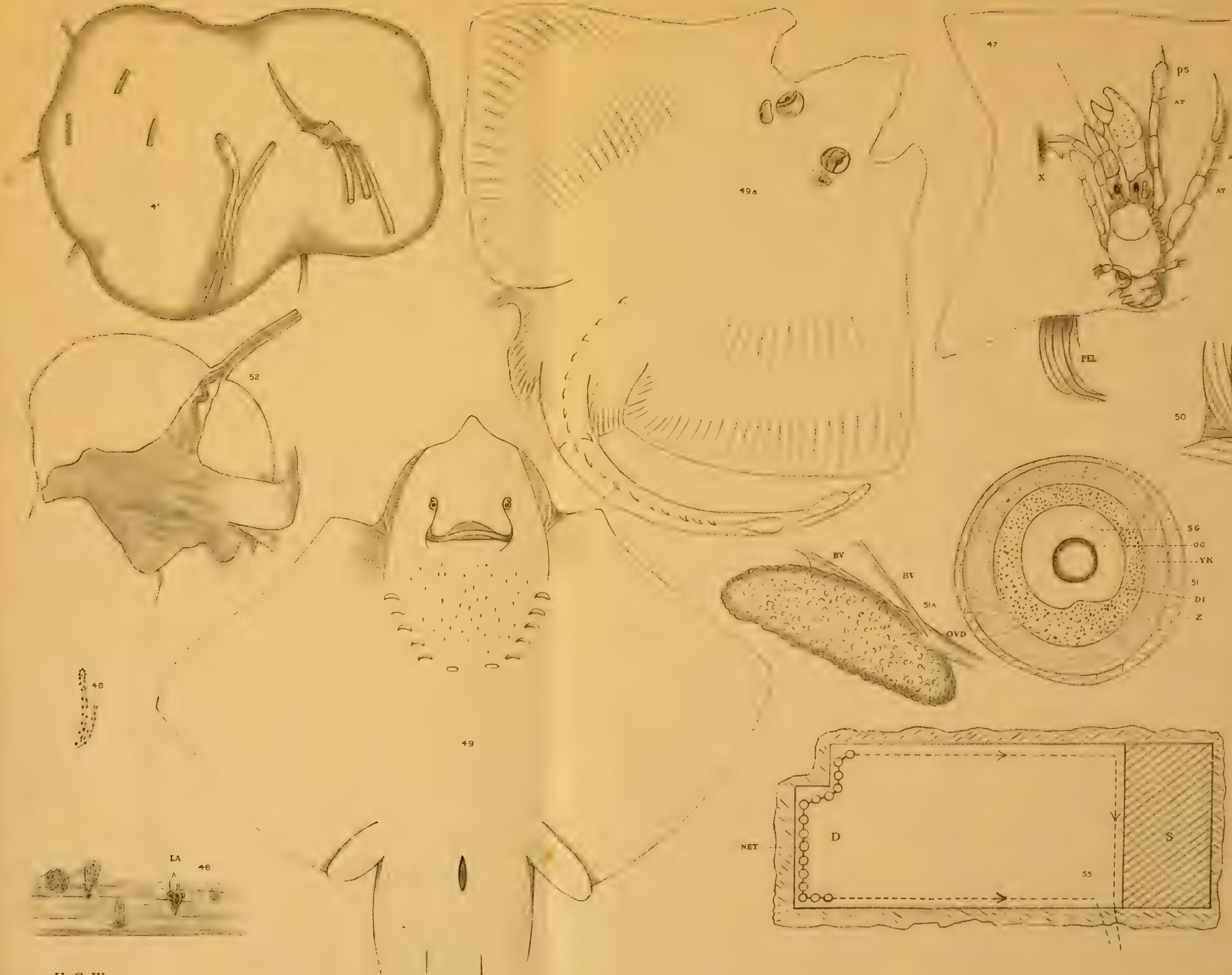
Gadus æglefinus, Gadus callarias, Zoarces viviparus, Raia circularis.

PLATE V.



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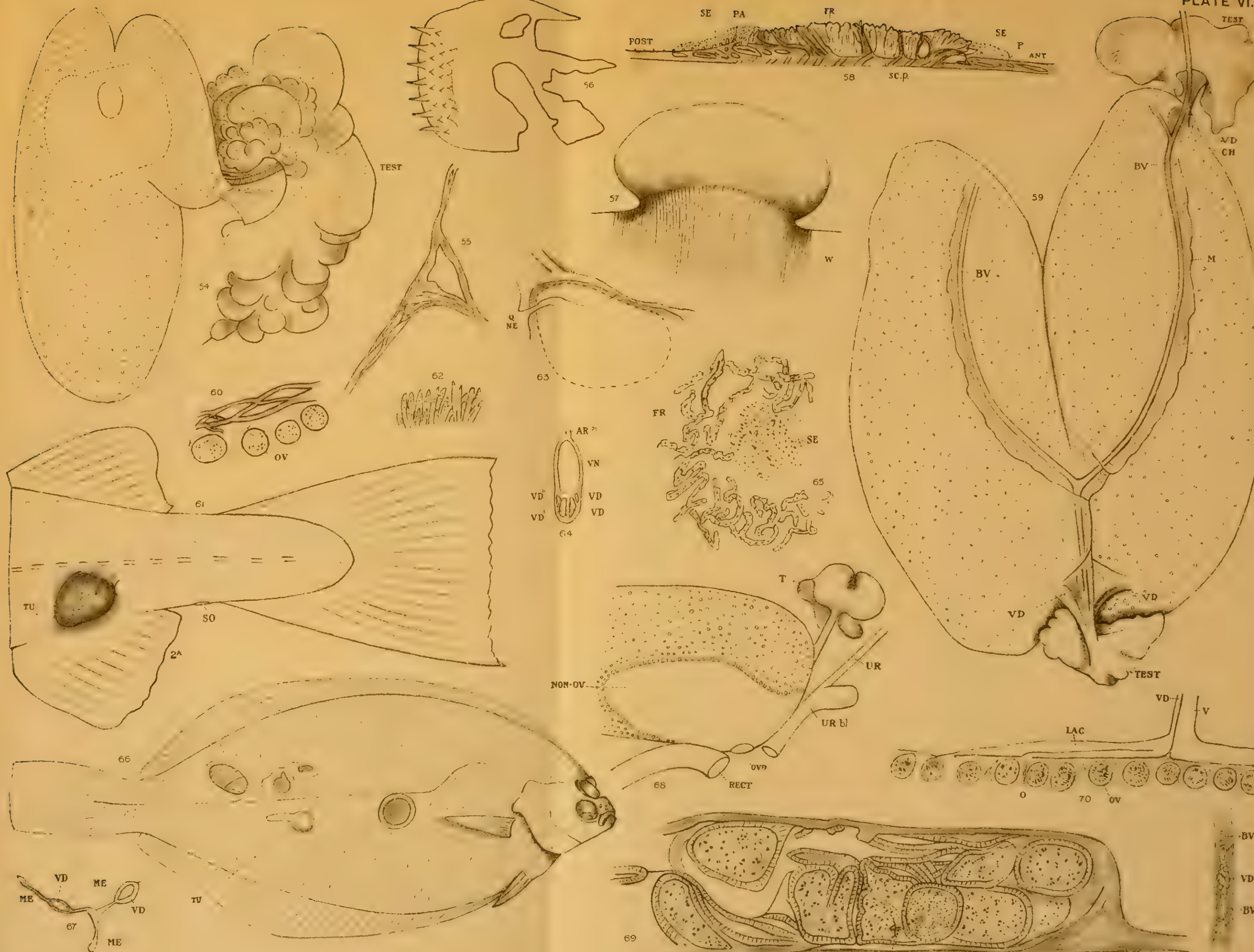
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H. C. W.

FIG. 29. Section through a scar on the shoulder of a *Gadus callarias*.
,, 30. Enlarged drawing of black spots (cysts) showing through four scales. *Gadus merlangus*.
,, 31. Cyst in the muscles of *Gadus callarias* which contained a nematode.
,, 32. Enlarged drawing of one of the black spots (cysts) in the skin of *Gadus merlangus*.
,, 33. Section of the skin of *Gadus merlangus* to show the situation of the black cyst.
,, 34. Shoulder of *Gadus callarias*, with scars probably caused by Cephalopod Mollusc.

PLATE IV.

FIG. 35. Abdomen of *Gadus callarias* with encysted sand-eel.
,, 36. *Zoarces viviparus*, ventral view enlarged.
,, 37. Abnormal *Raia circularis*. Reduced a little.
,, 38. *Gadus æglefinus*, wall of abdomen with encysted sand-eel.
,, 39. ,, ,, ,, ,, ,, ,,
,, 40 ,, ,, ,, ,, ,, sand-eels.
,, 41. *Gadus callarias*, without a tail; hind end. *About nat. size.*
,, 42. Branchiostegal ray of a *Gadus callarias* having upon it a growth of Zoophytes.
,, 43. *Zoarces viviparus*, 11½ inches (29 cm.) long, having tumours in its body. Dorsal view.
,, 44. *Gadus callarias*, with sand-eel in the abdominal cavity.

PLATE V.

FIG. 45. Tumour from abdominal cavity of a *Gadus callarias*. Reduced.
,, 46. Nematode encysted in abdominal cavity of *Gadus callarias*. Enlarged.
,, 47. *Eupagurus bernhardus* in abdominal cavity of *Gadus callarias*.
,, 48. Nematode encysted in abdominal cavity of *Gadus callarias*. *About nat. size.*
,, 49. Abnormal *Raia clavata*. Reduced.
,, 49A. ,, ,, ,, ,,
,, 50. Enlarged drawing of muscles at angle of cleft in anterior region of abnormal *Raia clavata*. *Cp.* fig. 49.
,, 51. Egg of *Brosmius brosme*. Enlarged.
,, 51A. Abnormal ovary of Haddock, p.
,, 52. Interior of tumour found in the abdominal cavity of *Gadus callarias*. *Cp.* fig. 45.
,, 53. Plan of pond at Laboratory. Scale, 1 mm.—1 foot.

PLATE VI.

FIG. 54. Hermaphrodite reproductive organ of Cod (*Gadus callarias*).
,, 55. Section through the wall of ovary at junction of right and left ovaries. Hermaphrodite cod (fig. 59).
,, 56. Scale from outside of tumour of *Pleuronectes microcephalus*.
,, 57. Tumour on outside wall of stomach of *Gadus callarias*.
,, 58. Longitudinal section of tumour on tail of *Gadus callarias* (fig. 61).
,, 59. Hermaphrodite reproductive organ of *Gadus callarias*.
,, 60. Section of wall of ovary of preceding (fig. 59), showing lacunæ.
,, 61. Tumour on tail of *Gadus callarias*. × $\frac{1}{3}$.
,, 62. Tubules on surface of frill from tumour shown in fig. 61.
,, 63. Inside surface of stomach. The dotted line indicates the position of the tumour (fig. 57).
,, 64. Section through *vasa deferentia* and vein of anterior testis (fig. 59).
,, 65. Surface view enlarged of part of tumour (fig. 61).
,, 66. *Pleuronectes microcephalus*, with tumours on the skin.
,, 67. Section through the mesenteries and *vasa defernia* connecting the hind testis to the ovary (fig. 59).
,, 68. Side view of ovary and hind testis (fig. 59).
,, 69. Section through tumour on skin of *Pleuronectes microcephalus*.
,, 70. Semi-diagrammatic section of wall of ovary showing chambers in it (fig. 59)
,, 71. Section through stalk connecting the testis to ovary (fig. 54).

VII.—NOTES ON SOME TREMATODE PARASITES OF FISHES.

By Thomas Scott, LL.D., F.L.S.

(Plates VII., VIII.)

One or two papers on parasitic Trematodes of fishes have already appeared in Part III. of the Annual Reports of the Fishery Board for Scotland, published in previous years. In the present paper four species, in addition to those previously published, are recorded, one of which appears to be undescribed.*

TREMATODA.

Fam. Tristomatidæ.

Genus *Callicotyle*, Diesing (1850).

Character.—Body thin, tolerably expanded; posterior sucker discoidal, nearly sessile, and provided with seven rays and two spines; the mouth without suckers.

Callicotyle affinis, new species. Pl. VII., fig. 1.

The Trematode recorded here has a close resemblance to *Callicotyle kröyeri*, Diesing, found on various kinds of skates (*Raia clavata*, *radiata*, and *batis*), but one or two obvious differences prevent its inclusion in the same species, and as I do not know of any other to which it can be ascribed, the name *Callicotyle affinis* may be given to it.

It differs from *Callicotyle kröyeri* in size, being nearly one and a half times longer; in shape it is broadly ovate, and the greatest width, which is near the middle, is equal to rather less than half the length; the width of the posterior half does not vary much, but the anterior half becomes gradually narrower towards the bluntly rounded apex.

The posterior sucker is transversely broadly ovate, the width exceeding the length by about one-fifth; the anterior margin is broadly and evenly rounded, but the margin opposite is flattened and somewhat sinuate. Interiorly this sucker has, like that of *Callicotyle kröyeri*, seven submarginal compartments and a central one; the lowermost of the seven compartments is in the middle line, and has on each side a slightly curved tooth; the centre compartment is not round as it is in *Callicotyle kröyeri*, but transversely narrow. There are apparently no suckers at the anterior end, and in this respect it also agrees with *Callicotyle kröyeri*.

The length of the specimen represented by the drawing (fig. 1) is 9 mm.

Habitat.—Parasitic on the gills of *Chimera monstrosa*, Linné, captured in the North Sea, January 1910. Apparently rare.

Fam. Polystomatidæ.

Posterior suckers more or less numerous.

Genus *Octobothrium*, Leuckart (1828).

Trematodes provided with eight posterior suckers and usually with a small one on each side of the mouth at the anterior end.

* I am indebted to my colleague, Dr. Williamson, for the privilege of examining the fishes on which the organisms recorded here were obtained, and to my son, Andrew Scott, A.L.S., for the drawings and photographs.

Octobothrium leptogaster, Leuckart. Pl. VII., figs. 2–5.

1842. *Octobothrium leptogaster*, Leuckart, Zool. Bruchst., vol. iii., p. 25, Pl. I., fig. 5; Pl. II., fig. 2.

In this species the posterior end is considerably expanded, and the eight suckers, which are moderately large, are situated at the ends of short finger-like processes which are spread out in the form of a fan. The body is extremely slender, especially the posterior portion extending from the fan-like expansion with its eight suckers, forward to the anterior thickened genital portion. This slender portion, which seems to have suggested the specific name, is much longer and more flexible than the anterior thickened part; along both sides of the thickened portion extends the vitelline gland in the form of two dusky longitudinal bands; the mouth, in the form of a narrow oval slit, is situated on the ventral surface near the anterior extremity. The pair of anterior suckers—one on each side of the mouth—observed in some species of *Octobothrium*, were apparently absent in *Octobothrium leptogaster*.

The posterior suckers (or *bothria*) are transversely and broadly ovate, the width being nearly equal to one and a half times the length; they are each furnished with about five spines: one springs from the anterior margin and, extending across the middle, divides the sucker into two nearly equal parts; the others are lateral and occur in pairs—two on each side; the smaller spine is nearly straight, but the larger is incurved and hook-like.

The eggs are of an oval shape, widest in the middle; width equal to about half the length, horn-coloured, and semi-transparent; length about 0·2 mm.; one end is produced into a short beak from which springs an exceedingly long and extremely slender colourless filament; the other end is without an appendage of any kind.

The entire length of the specimen represented by the drawing is 39 mm. The neck and body are marked by numerous faint transverse lines.

Habitat.—Parasitic on the gills of *Chimera monstrosa* captured in the North Sea in January, 1910; apparently not very rare.

Genus *Axine*, Abildgaard, 1795(4).

In this genus the posterior suckers are small and numerous.

Axine bellones, Abildgaard. Pl. VII., figs. 6–7.

1794. *Axine bellones*, Abild., Skift. af Naturhist. Selskab., t. iii., p. 59, tab. vi., figs. 3a, b.

1836. *Heteracanthus pedatus* et *sagittatus*, Diesing, Nov. Act. Nat. Cur., vol. xviii., i., p. 310, tab. xvii.

1850. *Axine bellones*, Diesing, Syst. Helminth, vol. i., p. 425.

1858. *Axine bellones*, P.-J. van Ben., Bull. de l'Acad. Roy. de Belg., vol. xxiii.

1858. *Axine bellones*, P.-J. van Ben., Acad. des Sci., Suppl. aux Comptes rendus, t. ii., p. 53.

1863. *Axine orphii*, P.-J. van Ben. and Hesse, Rech. sur la Bdellodes ou Herudinées et les Trématodes, p. 116, Pl. xii., figs. 19–27.

Body flat, thin, elongated; anterior extremity very attenuated, but becoming gradually wider towards the posterior end; posterior extremity expanded so as to assume the form of a hatchet ("hache"). The anterior end has the apex pointed, but it may also by contraction become emarginate (fig. 7). The mouth opening is denticulated and provided with two lateral, oval, and denticulated suckers. The genital aperture is of medium size and furnished with fasicles of minute teeth or hooks arranged partly vertical

and lateral. The posterior suckers, which are small and of an oval form, are each armed with four hooks, and each sucker appears to be divided into two nearly equal parts. The suckers seem to be supported on minute prominences and crowded together along the edge of the expanded membranous border which terminates the posterior end of the body. The number of suckers on the specimen represented by the drawing (fig. 6) is fifty-two. According to van Beneden, the suckers are mobile and can turn towards or away from each other, and that also by contraction to appear sometimes to be fewer in number and sometimes more numerous. Along the middle of the body and at the posterior extremity the colour is yellowish-white, while along each side is a dusky-coloured border.

The length of the specimen figured is about 10 mm., but others reach only to 8 or 9 mm., or are even smaller.

Habitat.—Parasitic on the gills of the sea pike or Gar-fish, *Ramphistoma belones*, Linn. (*Belones vulgaris*, Cuv.); captured in the North Sea about the end of April and beginning of May, 1910; apparently not very rare.

Genus *Amphiptyches*, Grube and Wagener (1852).

Amphiptyches urna, Grube and Wagener. Pl. VIII.

1852. *Amphiptyches urna*, G. and W., Müller's Archiv (1852). Pl. xiv.

Several examples, which include some apparently adult as well as others scarcely mature, were obtained in the intestine of specimens of *Chimera monstrosa* sent to the Laboratory at the Bay of Nigg from the Aberdeen Fish Market in January, 1910. The fish, it is understood, were captured in the North Sea.

Amphiptyches differs remarkably in its general appearance from the Entozoa usually met with in the intestines of marine fishes, while on the other hand it has a strong superficial resemblance to certain species of the Nudibranch mollusca. There also appears to have been at first some doubt as to the relationship between these parasites and the fish in which they were observed.

The parasite was described by Grube and Wagener in 1852 in Müller's Archiv, under the name of *Amphiptiches urna*. The specimens, along with the shells of *Mactra*—a Lamellibranch shellfish—were found in the intestine of *Chimera monstrosa* captured in the Mediterranean.

Diesing, in his Revision der Helminthen, 1858, ascribes this organism to his genus *Gyrocotyle*, and records it under the name of *Gyrocotyle amphiptyches*, Gr. and W.

In 1859 Dr. Paul Gervais and P.-J. van Beneden, in their work "Zoologie médicale," vol. ii., p. 193, after referring, under the sub-order Polycotylares Blainv., to various genera of the Tristomidae, proceed to remark that the *g. Amphiptyches* found by Grube and Wagener in the intestinal canal of *Chimera* appeared to be a parasite of that mollusc, and that its position in the fish was that of an erratic—a parasite that had lost its way by being accidentally swallowed by the *Chimera.**

In a further note, however, on these parasites published in his work on "Les Poissons des Cotes de Belgique" in 1870, Professor P.-J. van Beneden remarks that, having studied this singular worm only from specimens preserved in liquer obligingly communicated to him by G. Wagener, he had some doubt about them being internal parasites of fishes, and adds that, having since procured an adult *Chimera* captured on the coast of Norway,

* Le G. *Amphiptyches*, trouvé par Grube et G. Wagener dans le canal intestinal de la Chimère avec des coquilles de Mactre, pourrait bien être un parasite de ce dernier Mollusque, se trouvant à l'état erratique dans le poisson qui l'a fourni. Il n'y a en effet aucun autre ver polycotylaire vivant dans le tube digestif.

"we had the good fortune to find two *Amphiptyches urna* in its intestine, and we now conclude that it is an Nostosite,"* that is, a parasite that has now reached its ultimate destination, and therefore a true parasite of the *Chimera.*

In 1890, in Hist. Nat. des Annelés (coll. des Suites a Buffon), Vol. III., 2nd Part, the author, M. l'Professeur Léon Vaillant, mentions in a foot-note to *Gyrocotyle*, Diesing (p. 539), that this "must not be confounded with the *Amphiptyches*, Gr. and W., the unique species of which *A. urna* has been wrongly described under the name of *Gyrocotyle amphiptyches*, W., this last belonging to a group of Trematodes." But though *A. urna* is referred to in the statement just quoted as unique, there appears to be at least another species, *A. rugosa*, parasitic in a fish found in the South Seas. In the Memoir on Flatworms and Mesozoa by F. W. Gamble, in Vol. II. of the "Cambridge Natural History" (1896), the author not only refers to *Amphiptyches urna* and *A. rugosa*, but appears to regard them, not as Trematodes, but as Monozootic Cestodes belonging to a special family, the Cestodaria or Monozoa. The following are that author's remarks on this interesting point (p. 77):—

"Just as some Coelenterata (*Lucernaria*) may be regarded as not having advanced much beyond a scyphistoma stage, so there are unsegmental Cestodes (*e.g.*, *Archigetes*) which have remained as a slightly altered but sexual scolex, directly comparable with a Trematode, and, as all authors are agreed, representing one generation only. Such monozootic forms are now classed as a special family, the Cestodaria or Monozoa of which *Caryophylleus mutabilis* from the intestine of various Cyprinoid fish is the most abundant representative, while *Amphiptyches* (*Gyrocotyle*) *urna* from *Chimera monstrosa* of the Northern hemisphere is paralleled by *A. rugosa* found in *Callorhynchus antarcticus* from the Southern seas."

The specimens of *Amphiptyches* recorded by Grube and Wagener were found associated with the shells of *Mactra*; the specimens of *Chimera* from the Fish Market in which the parasites dealt with here were obtained had only a moderate quantity of food in their stomachs, which consisted of various organisms, chiefly small Crustacea, Echinoderms and Annelids, along with a few small Molluscan shells such as *Anomia*, *Pecten*, *Cardium*, *Buccinum*, *Fusus*, *Scalaria*, all of them small or immature. The parasites varied greatly in size—in length as well as in width. The longer specimens were narrow in proportion and the wider ones shorter. The longer specimens, such as that represented by fig. 1, measured fully 30 mm. by 10 mm. in width, while that represented by fig. 3 measured 24 mm. by 15 mm. The specimen represented by fig. 4 appears to be a young form. The specimens have the appearance of being incomplete, or as if they were segments of a larger form. They all occurred, however, as separate organisms; there was no sign of any being joined to one another, though considerable care was taken to ascertain if in any case that were so.

* Ce singulier ver a été trouvé d'abord par G. Wagener dans l'intestine de la Chimère de la Méditerranée; nous n'avons pu l'étudier que sur des individus conservés dans la liqueur, que G. Wagener nous a obligeamment communiqués; sont-ils de vrais parasites internes de ces poissons? Nous en avons douté, et nous pensions que ces magnifiques Trématodes étaient des parasites de quelque mollusque bivalve que le poisson avait avalés, c'est-a-dire, un parasite erratique, nous nous étions trompé. Ayant per nous procurer depuis une Chimère adult dans la liqueur, provenant de la côte de Norwége, nous avons eu la bonne chance de trouver deux *Amphiptyches urna*, adultes, dans l'intestin. Nous pouvons en conclure que c'est un Nostosite. *Cf. op. cit.*, p. 21.

EXPLANATION OF THE PLATES.

PLATE VII.

Callicotyle affinis, T. Scott.

Fig. 1. Underside of specimen to show posterior sucker, - - - × 17

Octobothrium leptogaster, Leuckart.

Fig. 2. Adult specimen, - - - - - - - × 5
Fig. 3. Anterior end, ventral aspect, - - - - - × 20
(*en.*, mouth: *ph.*, pharynx; *gp.*, genital aperture; *vg.*, vitelline gland.)
Fig. 4. Posterior end, ventral aspect, - - - - - × 30
Fig. 5. Three of the eggs removed, - - - - - × 105

Axine bellones, Abildgaard.

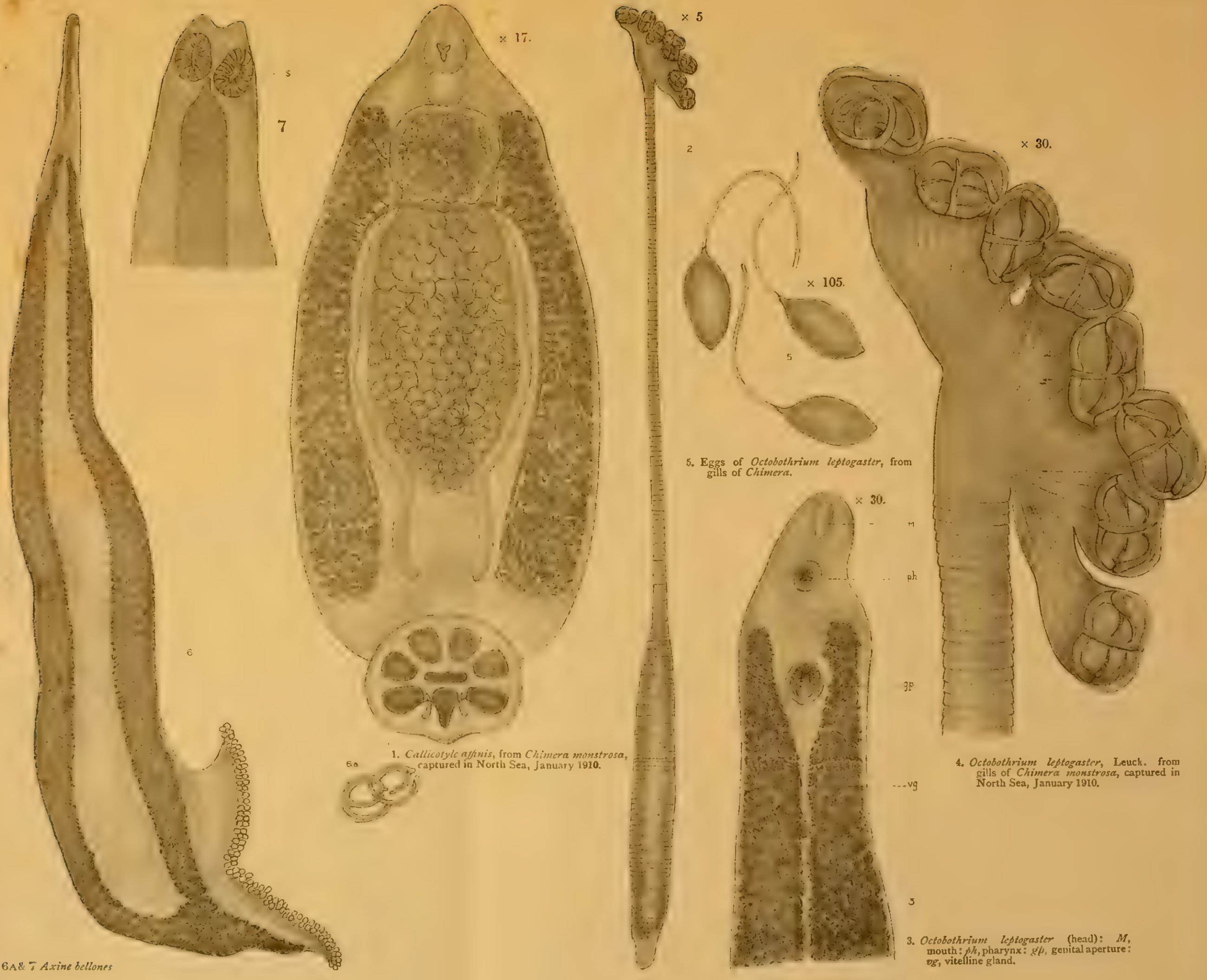
Fig. 6. Adult specimen, ventral aspect, - - - - × 20
Fig. 6*a*. One of the posterior suckers, - - - - - × 140
Fig. 7. Anterior end, ventral aspect (*s.*, anterior suckers), - - × 140

PLATE VIII.

Amphiptyches urna, Gr. and W.

Fig. 1. Specimen seen from above, . - - - - × 4·5
Fig. 2. Specimen seen from the side, - - - - - × 2·3
Fig. 3. Another specimen, seen from above, - - - - × 2·3
Fig. 4. A small (young ?) specimen, - - - . . × 2·3

PLATE VII.



1. *Callicotyle affinis*, from *Chimera monstrosa*, captured in North Sea, January 1910.

5. Eggs of *Octobothrium leptogaster*, from gills of *Chimera*.

4. *Octobothrium leptogaster*, Leuck. from gills of *Chimera monstrosa*, captured in North Sea, January 1910.

3. *Octobothrium leptogaster* (head): *M*, mouth: *ph*, pharynx: *gp*, genital aperture: *vg*, vitelline gland.

6, 6A & 7 *Axine bellones*

A. Scott, *del.*

1.

2.

4.

3.

A. Scott, Photo.

VIII.—A DESCRIPTION OF THE ADVANCED EMBRYONIC STAGE OF *LAMNA CORNUBICA*. By Edward W. Shann, B.Sc., Gatty Marine Laboratory, St. Andrews.

(Plate IX.)

Introductory.

Two well-advanced embryos of *Lamna cornubica*—the common porbeagle—together with the entire oviduct of the mother, were presented to the Zoology Department of St. Andrews University by Dr. H. C. Williamson, M.A., F.R.S.E. Professor M'Intosh kindly offered me the interesting task of describing this valuable material. While engaged upon preparing the notes for publication, the writer was fortunate in meeting Mr. H. Bolton, Curator of the Museum at Bristol, who offered for dissection another embryo of *Lamna*, which he had received from Dr. Williamson about three months previously. The Bristol specimen furnished not only a useful check on the observations made at St. Andrews, but, owing to slight structural differences, a clue to the manner of development. The fact that the latter specimen was examined at York will be used in distinguishing it from those which were examined at St. Andrews.

Before proceeding to the account of the work done, the writer wishes to express his gratitude to Professor M'Intosh, Dr. H. C. Williamson, Mr. H. Bolton, and Mr. James Ritchie for the use of material, and for answering patiently his numerous questions.

General Remarks.

The only literature on the subject which was forthcoming consisted of a short paper entitled "Notes on an Intra-uterine Specimen of the Porbeagle (*Lamna cornubica*)," by W. L. Calderwood.* This contained an account of the external features of a single embryo, measuring 10¼ inches, which was obtained from the uterus (oviduct) of an adult female at Aberdeen; unfortunately, Mr. Calderwood's drawings of this specimen were not published. Pennant† mentions a porbeagle which "had in its belly four young ones, each eight and twenty or thirty inches long." In a letter from Dr. Williamson, several instances of the occurrence of porbeagle embryos are mentioned, viz.:—"I sent one, obtained 29th March 1909, to the Scottish Museum. I "am under the impression that other specimens are there. Two specimens "are in the Laboratory here, but neither has a date. Mr. Ingram, Fishery "Officer, Leith, says that, so far as he can recollect, a female shark having "twins was obtained in a herring-net at Stornoway probably about June. "One large embryo of the porbeagle was sent by Mr. Ingram from Stornoway "to the Fishery Board's Laboratory. It is the largest I have observed. "The embryo is 19 inches in total length, and the yolk is very large, the "yolk-sac measuring 9¼ inches in length. The adult from which Mr. "Ingram obtained the twins was about five feet long." The embryos at St. Andrews measured 24 and 18 inches respectively in total length; the adult from which they were obtained measured about five feet. The specimen at

* *Sixth Annual Report of the Fishery Board for Scotland*, p. 263, 1887.
† Brit. Zool., Vol. III., p. 118.

York was 18½ inches long.* R. Collet† has measured various specimens of the porbeagle embryo from the Museums of Christiania and Trondhjem; he speaks of them as half-grown or rather more than half-grown. The adults which contained these embryos were taken on cod and halibut lines during the winter months. The following is a list of the embryos examined by Collet:—

"Selje, Nordfjord, 30th Dec. 1892; 1 embryo, 290 mm.

"Lyngen, W. Finmark, 1st Jan. 1891; 2 embryos, 295 mm.

"Rövaer, Stavangerfjord, 21st Feb. 1888; 4 embryos, 425 mm. (17 ins.).

"The adult containing the latter measured 2565 mm. (nearly 8½ feet). "The yolk-sac of the embryos had still a diameter of 185 mm. The "pectorals were 47 mm., the upper lobe of the caudal fin 121 mm., and "the lower 54 mm. in length.‡ These embryos would probably have been "born in April or May.

"A specimen (2800 mm., or over 9 feet) caught off the inner islands on "15th February 1905 contained three large embryos."

It is difficult to believe the report in the Memoirs of the Wernerian Society which states that "no fewer than thirty young ones appeared in the "belly of this female, fully formed and apparently ready for exclusion." This is the only record, among those examined, which gave more than four as the number of young at a birth for the porbeagle. Dr. Williamson says, "I do not know of any adult porbeagle having more than three young at a time." Two young at a birth is apparently the most frequent number, one being found in each oviduct.

An argument adduced by Mr. W. L. Calderwood§ may be quoted here:—

"The figure of the porbeagle given in Day's 'British Fishes' is taken from "a specimen only measuring 33 inches, and thus is not larger than those said "to be dissected from the adult by Pennant. It has quite the adult form. "From this, and from the statement of the Wernerian Society's Memoirs, "we may therefore surmise that at birth the young porbeagle has not only "assumed the matured shape of the parent, but has already absorbed all the "nourishment to be derived from the yolk-sac, which forms a conspicuous "object in the specimen under consideration."

It would appear, further, that the young porbeagle at birth measures approximately thirty inches. There is probably considerable variation in this respect, if we consider that porbeagle embryos have been observed measuring 10¼, 18, and 24 inches respectively, but all apparently at the same stage of development. It seems possible that the intra-uterine development of this shark may be divided into two fairly distinct periods, which may be styled (1) Formative and (2) Protective—the first, or Formative, period comprising the time during which the organs are developed, and terminated when the eyes, mouth, fins, etc., are fully formed, but the yolk-sac is still conspicuous; the second, or Protective, period during which the organs already formed simply increase in size at the expense of the yolk, and the uterus acts as a protection to the helpless young. This period ends when the yolk is entirely absorbed and the young fish is born in a condition to shift for itself. The duration of these periods is probably variable.

Detailed Measurements.

All the embryos examined were apparently females. There was no sign of claspers on their well-developed pelvic fins. No sexual glands were formed, but in the two examples dissected the oviducts were quite patent.

* Since writing this account I have been informed by Dr. Williamson that this embryo was obtained from the same adult as those which were examined at St, Andrews.—E. W. S.

† Meddelelser om Norges Fiske, 1 Aarene 1884-1901, p. 77.

‡ Compare with measurements in this memoir.

§ *Op. cit.*

One of the specimens at St. Andrews was considerably the shorter, and will be referred to in this memoir as specimen A. From specimen B, the larger, the yolk had been removed; this specimen was accordingly used for dissection, while the other was preserved for the Museum. The embryo examined at York will be referred to as specimen C.

The measurements in the appended table are in millimetres. Specimen C is placed between A and B in the table, since it was intermediate in size.

Region measured.	A	C	B
Tip of snout to base of caudal fin, ...	367	395	490
Caudal fin (round the curve) { Upper lobe, ...	145	135	168
Caudal fin (round the curve) { Lower lobe, ...	75	78	85
Tip of snout to anterior extremity of eye, ...	30	31	41
Width of eye socket, ...	11	11	14
Eye to nostril, ...	12	13	14
Eye to mouth, vertically, ...	18	18	18
Tip of snout to upper lip, ...	30	27	35
Width of head, eye to eye	44	44	51
Posterior extremity of lips to first gill slit, ...	47	40	52
Tip of snout to anterior end of 1st dorsal fin,	166	175	220
Length of 1st dorsal at base, ...	44	38	57
Vertical height of 1st dorsal, ...	30	31	52
Tip of snout to anterior end of 2nd dorsal fin,	325	335	423
Length of 2nd dorsal at base, ...	8	6	10
Vertical height of 2nd dorsal, ...	8	9	12
Base of pectoral fin, ...	26	26	40
Length of pectoral, ...	67	69	85
Posterior of pectoral base to anterior of pelvic,	94	96	84
Base of pelvic, ...	11	10	21
Length of pelvic, ...	29	29	35
Base of anal fin, ...	9	8	10
Length of anal, ...	9	9	14
Length of cloaca, ...	19	18	25
Anterior of cloaca to base of caudal, ...	100	120	125
Anterior of lower lip to chin pit, ...	32	...	65
Chin pit to anterior end of yolk sac, ...	50	...	54
Girth of yolk-sac at contact with body, ...	325	333	...
Maximum girth of yolk-sac, ...	545	568	...
Girth of yolk-sac from flank to flank (not allowing for body width), ...	360	385	...

External Appearance.

The young porbeagles closely resemble the adult in external features, except for the presence of the bulky yolk-sac (Pl. IX., fig. 1). The cylindrical body lies in a somewhat curved posture over the large ovoid yolk-sac, with which it is in contact between the pectoral and pelvic fins for a distance of 100 mm. The dorsal aspect of the head is flattened. The snout is much blunter than that of the adult. The nasal apertures are connected by a furrow. There is a chin pit on the ventral aspect of the head, situated a few centimetres behind the lower lip; in specimen C there was no distinct pit, the under surface in the branchial region forming a shallow concavity, rounded in front, to which the anterior projection of the yolk-sac is closely applied. The inter-nasal furrow and chin pit are embryonic characters, and are not found in the adult. The eyes and mouth are well developed, the latter containing a few small teeth. The latter do not show the two lateral cusps said to be present in the adult.

The presence or absence of spiracles in *Lamna cornubica* is still an open question. Sir William Turner* describes minutely the spiracles in a young female measuring 3½ feet, but these were only wide enough to admit the passage of a pig's bristle. Spiracles are also said to be present by Müller and Henle, in their work on the *Plagiostomata*, by Yarrell in his "British Fishes," and by Duméril in his "Hist. Nat. des Poissons." Fleming, Couch, and Parnell state that they are wanting. Day compromises with the remark, "Spiracles, if present, minute;" Tate Regan, in his "Classification of the Selachian Fishes," agrees with this conclusion. Günther found no spiracles in *L. cornubica*, but states that "a minute pore-like foramen could be seen "on one side of an example of *L. spallanzani*." Mr. W. L. Calderwood,† in describing his embryo porbeagle, says:—"In this young specimen the "skin between the eye and gill slits was very soft and much wrinkled, and "although examined carefully with a lens revealed no aperture." The result of a similar examination of the specimens at St. Andrews corroborated this statement; in the specimen at York, however, a small pit was observed on either side of the head, level with the centre of the eye, and in each case 22·5 mm. from the margin of the latter. The position agrees well with that observed by Sir W. Turner,† but some doubt remains whether these were actually the openings of spiracular canals or merely surface pits. They would not admit the passage of a hair; and when a fine surgical wire was used, it was found that the wire did not follow a definite channel, but forged a course for itself through the soft vacuolated tissues. The tissues were unfortunately too soft for sectioning, or some evidence might have been obtained in this manner. Careful examination did not reveal an internal spiracular aperture in the pharynx.

The minute spiracles which have been found in adult porbeagles by various observers can be of very little use to the fish; if they were of vital importance they would be present invariably. It is probable, then, that the spiracles of *Lamna cornubica* are abortive structures. By the law of recapitulation, the spiracle is formed in the embryo, but disappears in most cases before, or soon after, birth. This interpretation of the facts is only an hypothesis, and must await further investigations.

The five gill slits were open and the gills fully developed. All the fins were normal with the exception of the caudal, whose dorsal and ventral lobes had not yet expanded, but had a chelate appearance. The keel on the sides of the posterior end of the body, also the notch in the back at the base of the caudal fin, were characteristic. The skin was slightly roughened with developing scales (Plate IX., fig. 2). The colouring of the trunk and fins was normal; the yolk-sac was yellow. The cloaca was open.

Owing to the courtesy of Mr. James Ritchie, M.A., B.Sc., the writer was enabled to examine the porbeagle embryo which was sent by Dr. Williamson to the Royal Scottish Museum. This form was a female (?)‡ measuring 21¾ inches in total length, and the yolk-sac was still of enormous bulk. The young fish was slightly better developed than those examined at St. Andrews. The inter-nasal groove had almost disappeared, the teeth were numerous, and the chin-pit was almost filled out, being only represented by two grooves which ran from the first gill slit towards the point where the pit was formerly placed. In this example, too, a pair of minute pits were observed an inch behind the margin of the eye, one on each side of the head. It was not clear whether the pits communicated with an internal passage. It was not possible to effect an entry with a hair or waxed thread. This is a similar condition to that recorded above for specimen C, and seems to render it yet more probable that these pits have some connection with the problematical spiracles.

* *Journ. Anat. and Phys.*, 1875, p. 301.
† *Op. cit.*
‡ I did not see the interior, but there were no traces of claspers.

Internal Examination of Specimens B and C.

Both surfaces of the wall of the yolk-sac were smooth; the wall was very thin except where it approached the body-wall. The wall was well supplied with blood vessels, whose ramifications could be plainly seen. The yolk formed a dense mass of a pale yellow colour. It was applied closely to the wall of the sac, and found its way into every interstice of the body-cavity, investing completely the abdominal organs. The œsophagus lead into a funnel-shaped organ, whose wide distal end opened freely into the substance of the yolk (Plate IX., fig. 3). The œsophagus was thick-walled, and bore marked longitudinal ridges on its inner surface. The wall of the funnel also showed ridges of thickening at its proximal end, but became thin at the distal end. The margin at the open end was deeply serrated. A lobed mass of tissue was found adhering to the outer wall of the funnel, but its function was not ascertained; it is shown in Plate IX., fig. 3 (*l.t.*). A thick-walled narrow tube lead from the funnel to the spiral intestine. The stomach did not appear to exist as such at this period. The connecting tube mentioned above, and depicted in Plate IX., fig. 3 (*c.t.*), was slung from the œsophagus by a tough mesentery. It entered the wall of the funnel where the latter began to dilate, and ran in the wall of the funnel for a short space, finally opening into the funnel. As before stated, this tube enters the spiral intestine; if this portion of the connecting tube is persistent it probably becomes the pylorus of the adult, and accounts for the remarkable constriction at the entrance to the spiral intestine. The intestine lead into the rectum, which opened into the cloaca. The rectal gland was a club-shaped diverticulum opening into the rectum on its dorsal aspect.

The large bi-lobed liver occupied the greater part of the abdominal cavity anteriorly. The oviducts were formed, but, as was previously mentioned, there were no traces of ovaries. The kidneys could be seen on the dorsal wall of the body cavity. A pair of tubes lying anteriorly to the kidneys were thought to be the abortive anterior portions of the Wolffian ducts.

The brain and nervous system were much decomposed, but had apparently reached their full development. The spinal column was composed almost entirely of sectile cartilage, which, however, showed signs of incipient thickening in certain areas, foreshadowing the osseous plates in the vertebræ of the adult which have been described by Owen* and by Tate Regan.† The notochord persisted as a transparent gelatinous substance in the inter-spaces between the vertebræ.

The oral and pharyngeal linings were beset with hollow papillæ throughout the area which Imms‡ has described as covered with denticles in a specimen measuring 790 mm. (about 31 inches). Microscopic examination failed to reveal denticles, even in an incipient condition, in the skin of the mouth and pharynx of the embryos under consideration.

The most noteworthy feature of the internal structure was the condition of the arterial arches. In the majority of the present-day sharks, with the exception of the Notidanoidei, the ventral aorta breaks up into five arches. The posterior pair of afferent branchials leaves the ventral aorta on its dorso-lateral aspect, and supplies the fifth gill pouch. The next two arches, that is to say the fourth and third afferent branchials, leave the ventral aorta on its lateral aspect at varying intervals. Anteriorly the ventral aorta bifurcates, and its right and left branches thus formed bifurcate again to give the second and first aortic arches. This condition was realised in the young porbeagles, but in specimen B in addition there was a sixth aortic arch, whose branches left the ventral aorta on the dorsal aspect slightly posterior to the origin of the fifth aortic arch (Plate IX., fig 4). The origins of these vessels were

* The Anatomy of Vertebrates, Vol. I., p. 33.
† *Proc. Zool. Soc.*, 1906, p. 742.
‡ *Proc. Zool. Soc.*, 1905, Vol. I., p. 44.

perfectly distinct up to the point where they joined the ventral aorta. They differed from the five normal arches in this, viz., that they did not supply a gill pouch, but running almost directly backwards, and then outwards, they ramified among the muscles of the body wall. In specimen C the sixth arch was found, but the vessels were smaller and more delicate than those in specimen B; moreover, they never actually entered the ventral aorta, but ended blindly in connective tissue immediately posterior to the origin of the fifth pair of afferent branchials.

The only literature which threw any light upon this subject was the following extract from Milne' Edwards "Leçons." Speaking of the aortic arches of fishes, he says :—" Les crosses aortiques se constituent successivement d'r " avant en arrière, et l'on en compte jusqu' à sept paires; mais il est rare " que tous ces vaisseaux aient une existence permanente, et, le plus " ordinairement, les premiers formés s' atrophient et disparaissent avant que " les derniers se soient bien constitués; enfin d'autres fois quelques-uns de " ceux-ci paraissent avorter, de sorte que, chez l'animal parfait, le nombre " de ces arcs vasculaires ne dépasse que rarement quatre ou cinq paires."

In the case of the porbeagle, it would appear on the contrary that the posterior, or last formed, arterial arch atrophies; for it is this posterior arch which is not found in the adult Selachian.

From the evidence of these aortic arches, it appears highly probable that during the younger stages of the development in *Lamna cornubica* there may be a kind of placental connection between mother and young. It has been shown that the body-wall is continuous with the wall of the yolk-sac; further, that a supply of blood reaches the body-wall direct from the heart. If, at an earlier stage than that under consideration, the wall of the yolk-sac was actually in organic connection with the ridged inner wall of the uterus (which is also well supplied with blood vessels), it is quite possible to conceive that the venous blood brought by the sixth aortic arch to the wall of the yolk-sac might be aerated by arterial blood in the uterine wall. When the gills were formed this method of respiration would no longer be necessary, and the accessory sixth aortic arch would atrophy. In specimen C one might point out that such an occurrence is in the act of taking place. The weak point in this idea is the fact that there is no trace on the wall of the yolk-sac of any such organic connection as was postulated.

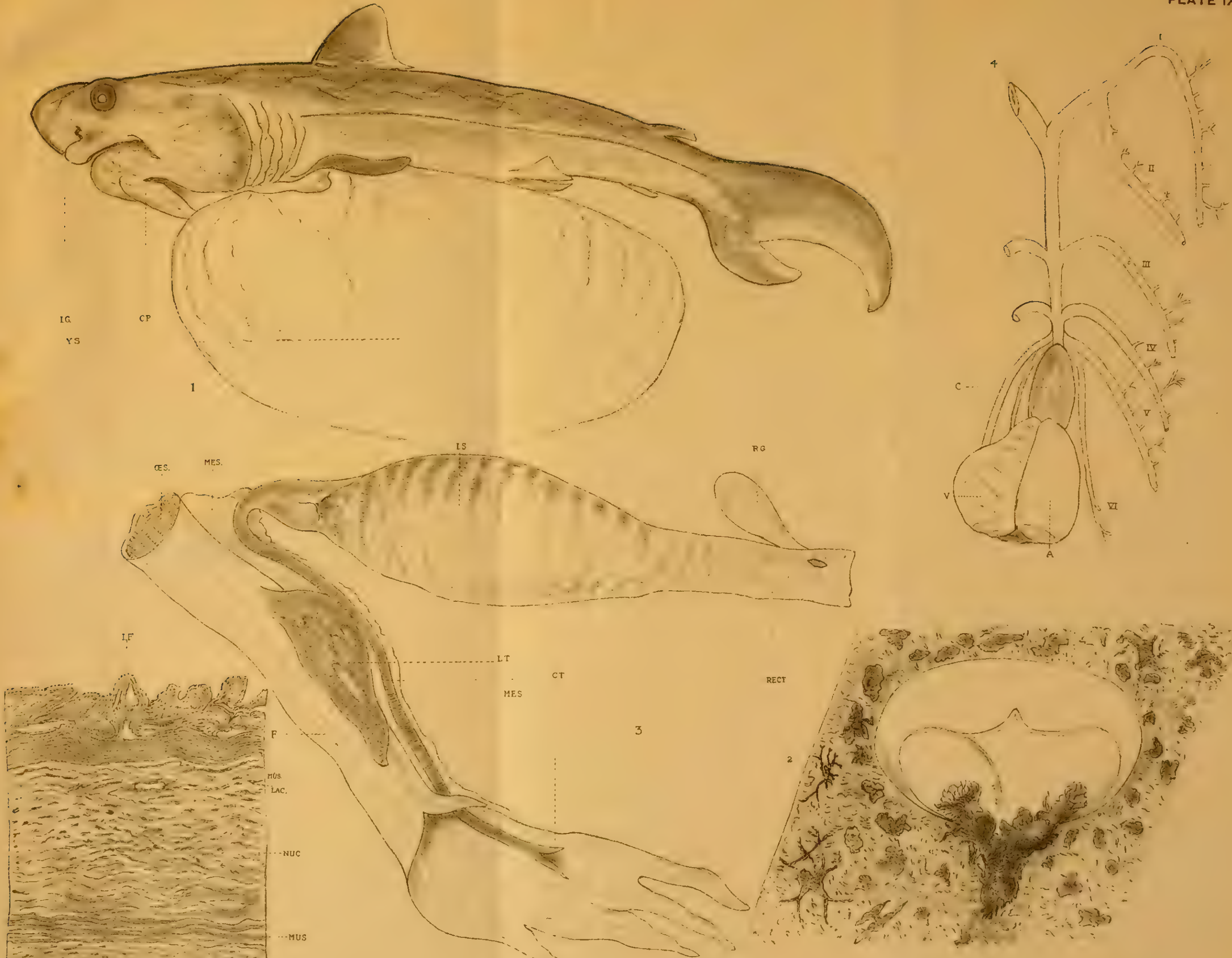
The Uterus (Oviduct) of the Adult.

The adult female which contained the two embryos A and B which have been described above, measured about five feet in total length. Each oviduct was 23 inches in total length. The oviducts were united by tough mesentery throughout their length. The anterior portion of the oviduct was closed by a dense network of tissue. The uterine portion was very much swollen in order to contain the large embryos; each oviduct contained one of the latter. The uteri united at the posterior end, ran parallel with one another for two inches, then opened by a common muscular tube about three inches in length.

The uterine wall was of a leathery nature. The external surface was smooth, the internal thrown into ridges and furrows. At the anterior end of the uterus the inner wall showed the highest ridges; these were in the form of longitudinal folds, between which lay smaller elevations. The remainder of the internal surface of the uterus was ridged in all directions, the ridges growing less conspicuous towards the posterior end. No villi comparable with those described by M'Intosh* for *Zoarces viviparus* were observed.

In transverse section (Plate IX., fig. 5) the uterine wall showed an outer layer of compact cells, next a deep layer consisting of a series of muscle fibres and nucleated cells, and finally a dentate layer composed of small

* *Annals and Mag. of Nat. Hist.*, June, 1885.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E. W. Shann, *del.*

cells. In the middle layer there was an upper and a lower stratum composed entirely of closely-packed muscle fibres, between which occurred a more loosely-packed stratum. The latter stratum consisted of nucleated cells among which were found a few muscle fibres; the uterine blood vessels lay in this stratum. This fact is also opposed to the supposition of a placental connection.

EXPLANATION OF THE FIGURES IN PLATE IX.

FIG. 1. Embryo A Reduced from drawing × ½. *i.g.*=inter-nasal groove. *c.p.*= chin pit. *y.s.*=yolk-sac.

,, 2. Skin of embryo B. Reduced from drawing × 475. Showing pigment spots and a dermal denticle in the process of development.

,, 3. Digestive tract of embryo C. Reduced from drawing × 1. *œs.*=œsophagus. *f.*=funnel. *l.t.* = lobed tissue mass. *c.t.*=tube leading to intestine. *i.s.*=spiral intestine (slit open). *rect.*=rectum. *r.g.*=rectal gland.

,, 4. Heart and branchial arches of B. Reduced from drawing × 1. Ventral aspect. I.-VI.=first to sixth afferent branchials.* *c.*=conus arteriosus. *v.*=ventricle. *a.*=auricle.

,, 5. Transverse section of uterine (oviducal) wall of adult. Reduced from drawing × 20. *i.f.*=internal folds. *mus.*=muscle fibre strata. *nuc.*=muscle fibres and nucleated cells. *lac.*=blood lacuna.

* In the light of the probable function of the sixth arterial arch it is perhaps inadvisable to speak of it as an afferent branchial.